AD-A054 034 ARINC RESEARCH CORP ANNAPOLIS MD F/G 19/6

ENGINEERING ASSESSMENT OF COASTAL PATROL AND INTERDICTION CRAFT--ETC(U)

SEP 74 J D BROGLIO, G P METTLER, A N WINTER N00197-74-C-0506

UNCLASSIFIED 1625-01-1-1353 NL

1 OF 2

AD A054034

Publication 1625-01-1-1353

FOR FURTHER TRAN

8

FINAL REPORT

ENGINEERING ASSESSMENT OF COASTAL PATROL AND INTERDICTION CRAFT (CPIC) WEAPON SYSTEM

SEPTEMBER 1974

Prepared for
NAVAL ORDNANCE STATION
LOUISVILLE, KENTUCKY
under Contract N00197-74-C-0506

ARINC RESEARCH CORPORATION

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 1625-01-1-1353	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ENGINEERING ASSESSMENT OF COASTAL PATROL AND INTERDICTION CRAFT (CPIC) WEAPON SYSTEM		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER 1625-01-1-1353
7. AUTHOR(s) J.D. Broglio, W.J. Wysocki, G.P. Mettler, A.N. Winter		8. CONTRACT OR GRANT NUMBER(s) N00197-74-C-0506
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARINC Research Corporation, 2551 Riva Road, Annapolis, Maryland 21401		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS NAVAL ORDNANCE STATION LOUISVILLE, KENTUCKY		12. REPORT DATE September 1974
		13. NUMBER OF PAGES 85
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) NAVAL ORDNANCE STATION LOUISVILLE, KENTUCKY		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNCLASSIFIED/UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

ARINC Research Corporation conducted an engineering assessment of the EX 30 Mod 0 30mm Weapon System aboard the Coastal Patrol and Interdiction Craft (CPIC). The system was examined, both by subsystem and as a complete entity, from a reliability and maintainability perspective. Potential reliability and maintainability problems were identified; and recommendations were developed for design changes that might improve the reliability, maintainability, and performance of the production systems.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

8

9 FINAL REPORT,

6 ENGINEERING ASSESSMENT OF
COASTAL PATROL AND INTERDICTION CRAFT (CPIC) WEAPON SYSTEM.

11 Sep~~tember~~ 1974

12 163p.

Prepared for
Naval Ordnance Station
Louisville, Kentucky
under Contract N00197-74-C-0506
15

by

10
J. D. Broglio,
G. P. Mettler,
A. N. Winter
W. J. Wysocki

ARINC Research Corporation
a Subsidiary of Aeronautical Radio, Inc.
2551 Riva Road
Annapolis, Maryland 21401
Publication 1625-01-1-1353
14

400 247 JOB

ABSTRACT

ARINC Research Corporation conducted an engineering assessment of the EX 30 Mod 0 30mm Weapon System aboard the Coastal Patrol and Interdiction Craft (CPIC). The system was examined, both by subsystem and as a complete entity, from a reliability and maintainability perspective. Potential reliability and maintainability problems were identified; and recommendations were developed for design changes that might improve the reliability, maintainability, and performance of the production systems.

Preceding Page Blank - Filmed

SUMMARY

Under Contract N00197-74-C-0506, Tasks 1, 2, and 3, with the Naval Ordnance Station, Louisville (NOSL), ARINC Research Corporation assessed the EX 30 Mod 0 30mm Weapon System installed in the prototype Coastal Patrol and Interdiction Craft (CPIC), which is being developed for delivery to the Republic of Korea Navy (ROKN). This report summarizes the results of the work conducted in these three tasks.

The weapon system design, interface and installation documentation, and available test data were reviewed. ARINC Research personnel accompanied NOSL personnel to Korea to review the CPIC Ordnance Plan for Maintenance and the present maintenance practices and concepts employed by the ROKN. In addition, they observed the CPIC Weapon System night evaluation tests conducted in San Diego.

ARINC Research analyzed each subsystem and the weapon system in its entirety, predicting the reliability of the overall system and its constituent components. Maintainability was assessed in the light of the ROKN organization and capabilities observed during the ROK visit. Potential reliability and maintainability problems were identified.

Recommendations for improving the reliability, maintainability, and performance of the production systems were developed. These recommendations encompass design changes, alignment procedures, maintenance procedures, periscope improvement, power sources, stabilization, change control, and documentation.

Preceding Page Blank - Filmed

CONTENTS

CONTENTS (continued)

CHAPTER ONE

INTRODUCTION

Under the provisions of Contract N00197-74-C-0506 Tasks 1, 2, and 3 of 15 April 1974, ARINC Research Corporation assessed the EX 30 Mod 0 30mm Weapon System installed in the prototype Coastal Patrol and Interdiction Craft (CPIC), which is being developed for delivery to the Republic of Korea Navy (ROKN).

An in-depth review of the design, interfaces, and installation of the equipment and subsystems comprising the CPIC Weapon System was performed to provide an engineering assessment of the system. The reliability and maintainability aspects of the system were also examined in order to provide an indication of the probability that the weapon system would successfully complete various assigned missions.

The CPIC Weapon System comprises the following subsystems:

- Mk 93 Mod 0 Radar Gun Fire Control System, consisting of the Honeywell System Control Console (including the Honeywell H-316R computer) and KAAR LN66HP Radar
- Kollmorgen Mk 35 Mod 0 Remote Optical Director
- Emerson Electric Mk 74 Mod 0 Twin 30mm Gun Mount
- Oerlikon Hispano-Suiza HS 831 A/L 30mm Machine Guns
- Two VARO Frequency Converters: a three-phase, one kW; and a one-phase, five kW
- Sperry Mk 5 Mod 0 Gyro Stabilizer

An ARINC Research engineer accompanied U.S. Government representatives to the Republic of Korea to review the maintenance practices and concepts employed by the ROKN. These practices were analyzed to develop recommendations concerning the support of the CPIC Weapon System in Korea.

This study provides information necessary for reliability and maintainability decisions that must be made before a production CPIC Weapon System is developed.

Preceding Page Blank - Not Filmed

CHAPTER TWO

WEAPON SYSTEM DESCRIPTION

The Coastal Patrol and Interdiction Craft Weapon System was designed to provide a lightweight, rapid-fire, modern weapon system for use in the coastal areas of the Republic of Korea (ROK). The anticipated threats are small combatant surface craft and moderate-speed aircraft.

The CPIC EX 30 Mod 0 30mm Weapon System consists of the following subsystems:

- Mk 74 Mod 0 Gun Mount
- HS 831 A/L 30mm Machine Gun (two per mount)
- Mk 35 Mod 0 Remote Optical Director
- Mk 93 Mod 0 Gun Fire Control System
- Mk 5 Mod 0 Gyro Stabilizer
- Varo Model 100-152 1-kVA Frequency Converter
- Varo Model 100-153 5-kVA Frequency Converter

Figure 1 shows a typical CPIC with a single gun mount forward. Future systems may employ an additional Mk 74 mount aft of the directors on the pilot house.

Figure 2 depicts the CPIC weapon system; it should be noted that the xenon searchlight, pit log, and gyro compass are not considered part of the weapon system for this analysis. To supplement data from the sensors shown in this figure, the System Control Console (SCC) operator manually enters wind direction and speed.

Figure 3 shows the Mk 74 Mod 0 gun mount with two Hispano Suiza (HS) model 831 A/L 30mm machine guns. This mount can be operated either locally or remotely from the director.

Figure 4 is a simplified block diagram of the Radar Gun Fire Control System (RGFCS). The RGFCS includes the KAAR model LN 66 HP Radar and the system control console (including the Honeywell model H316R computer), which is shown in Figure 5.

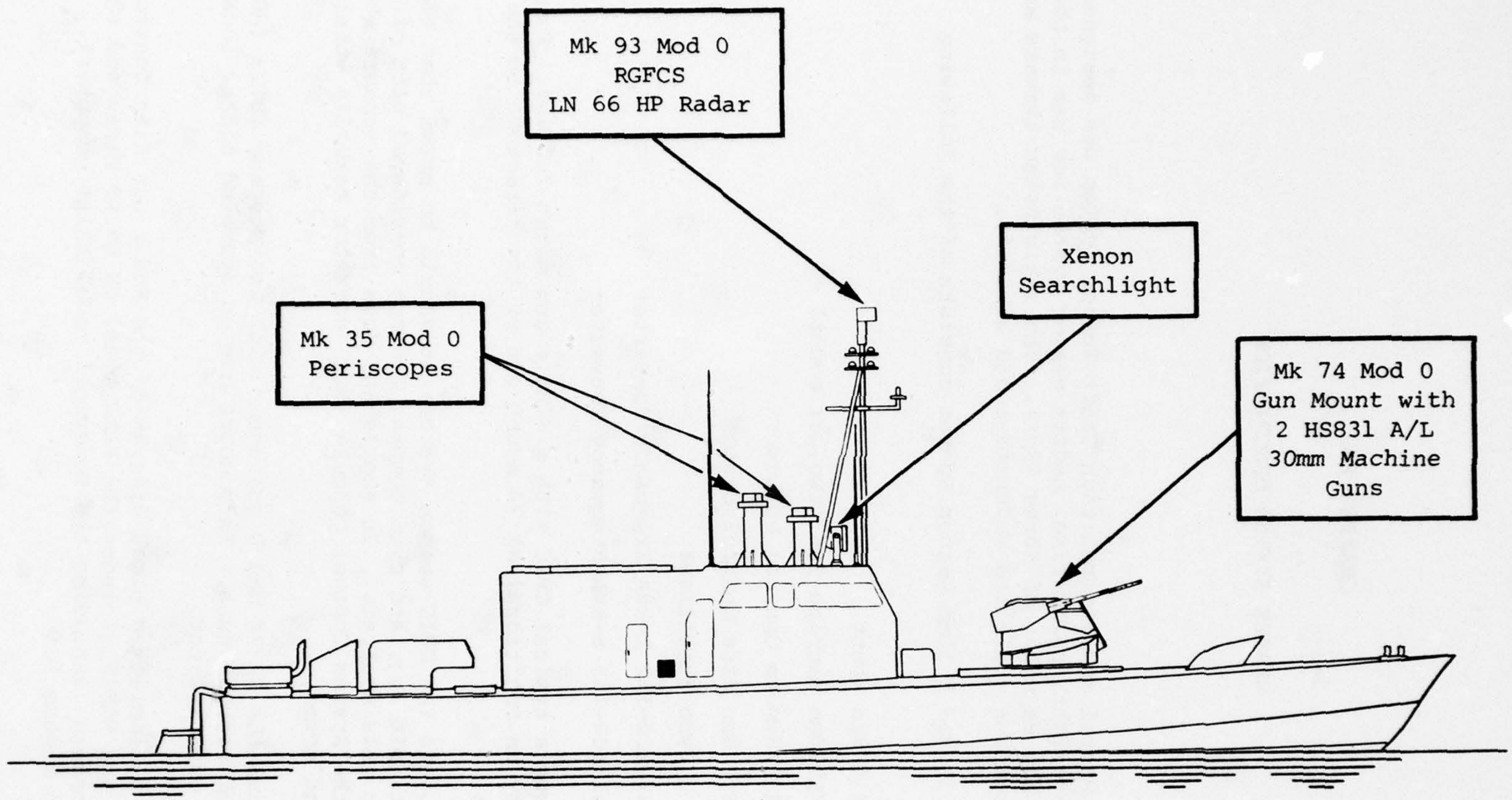


Figure 1. COASTAL PATROL AND INTERDICTION CRAFT

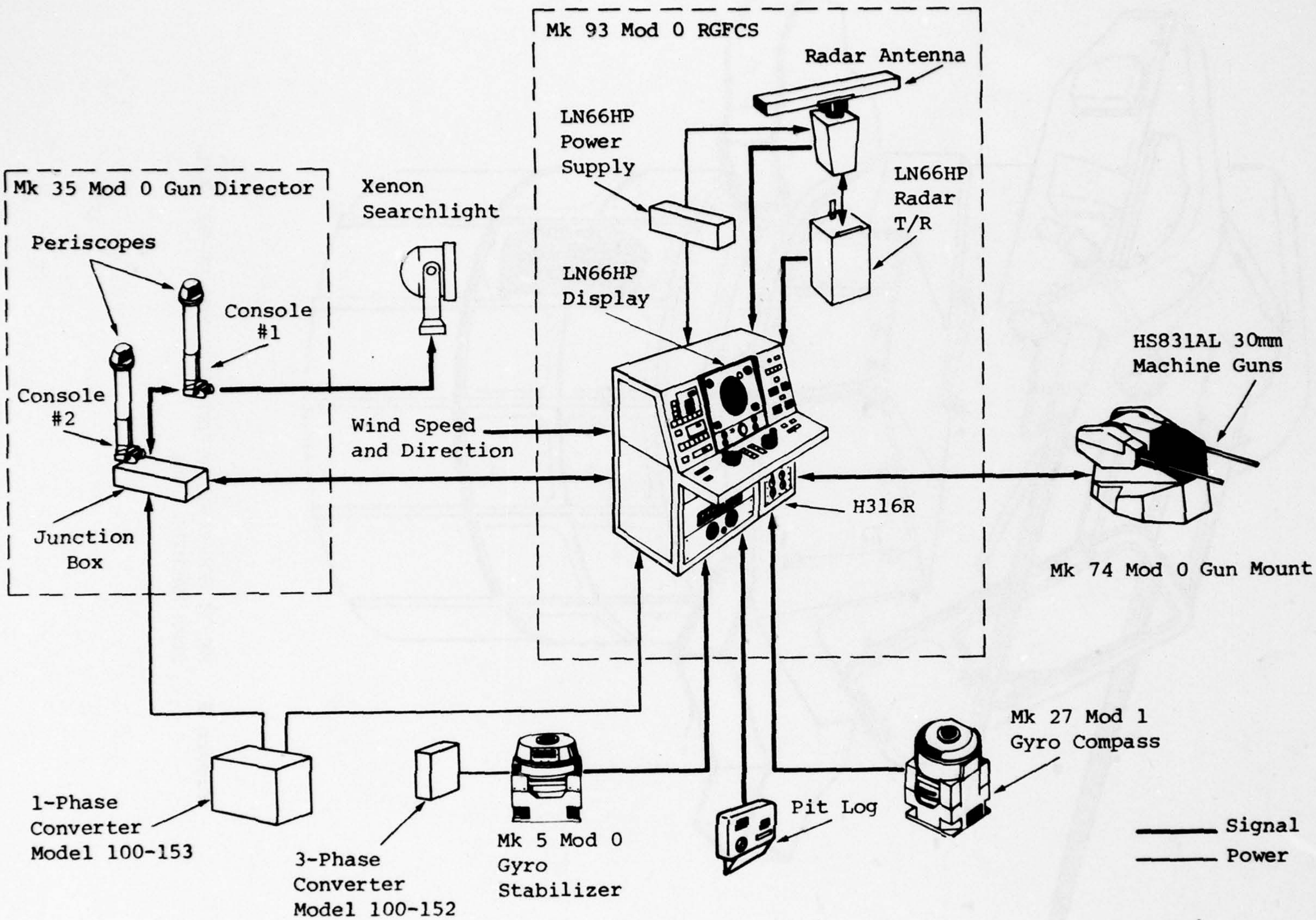


Figure 2. CPIC WEAPON SYSTEM

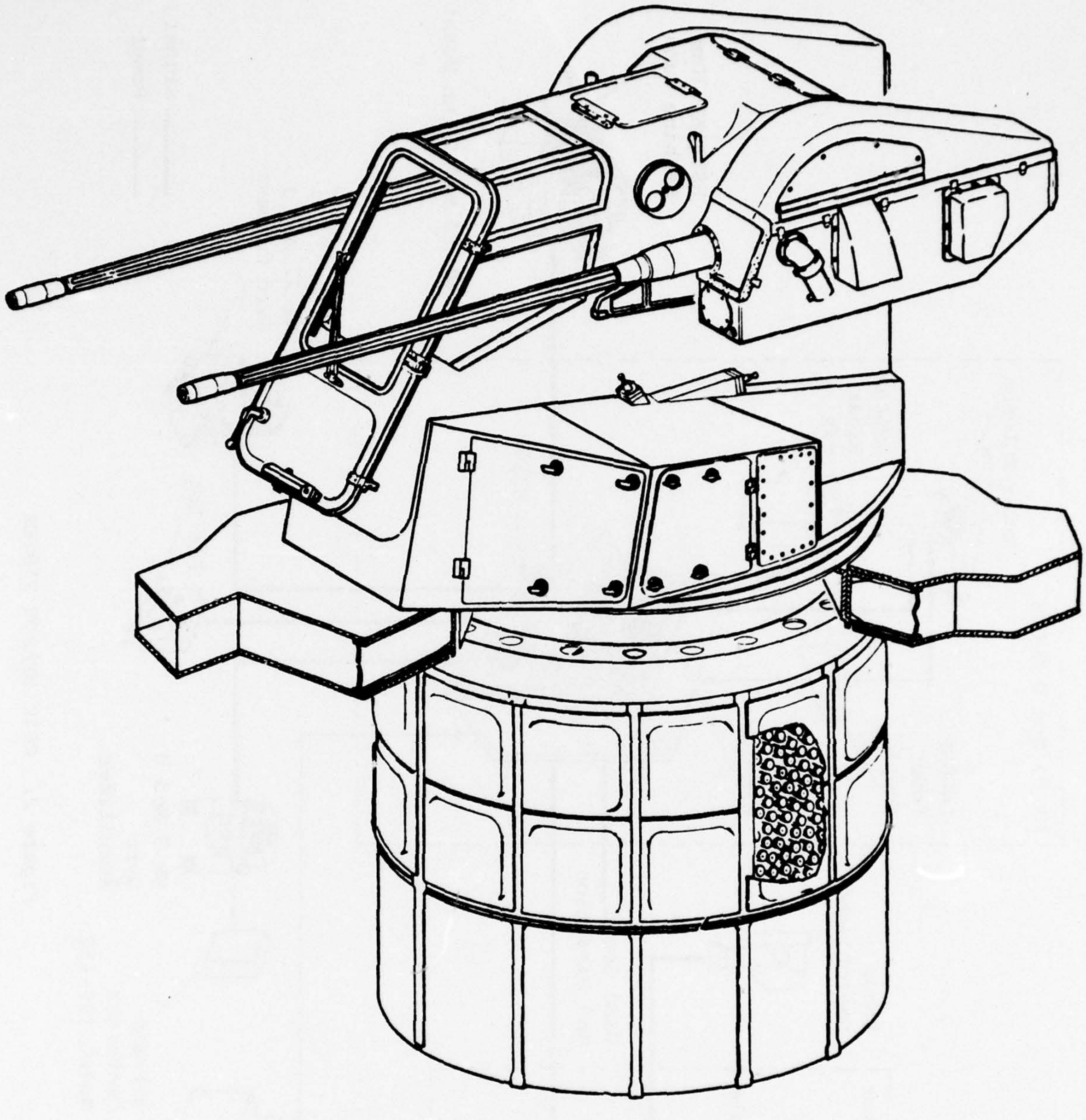


Figure 3. MK 74 MOD 0 GUN MOUNT WITH TWO HS-831 A/L 30MM MACHINE GUNS

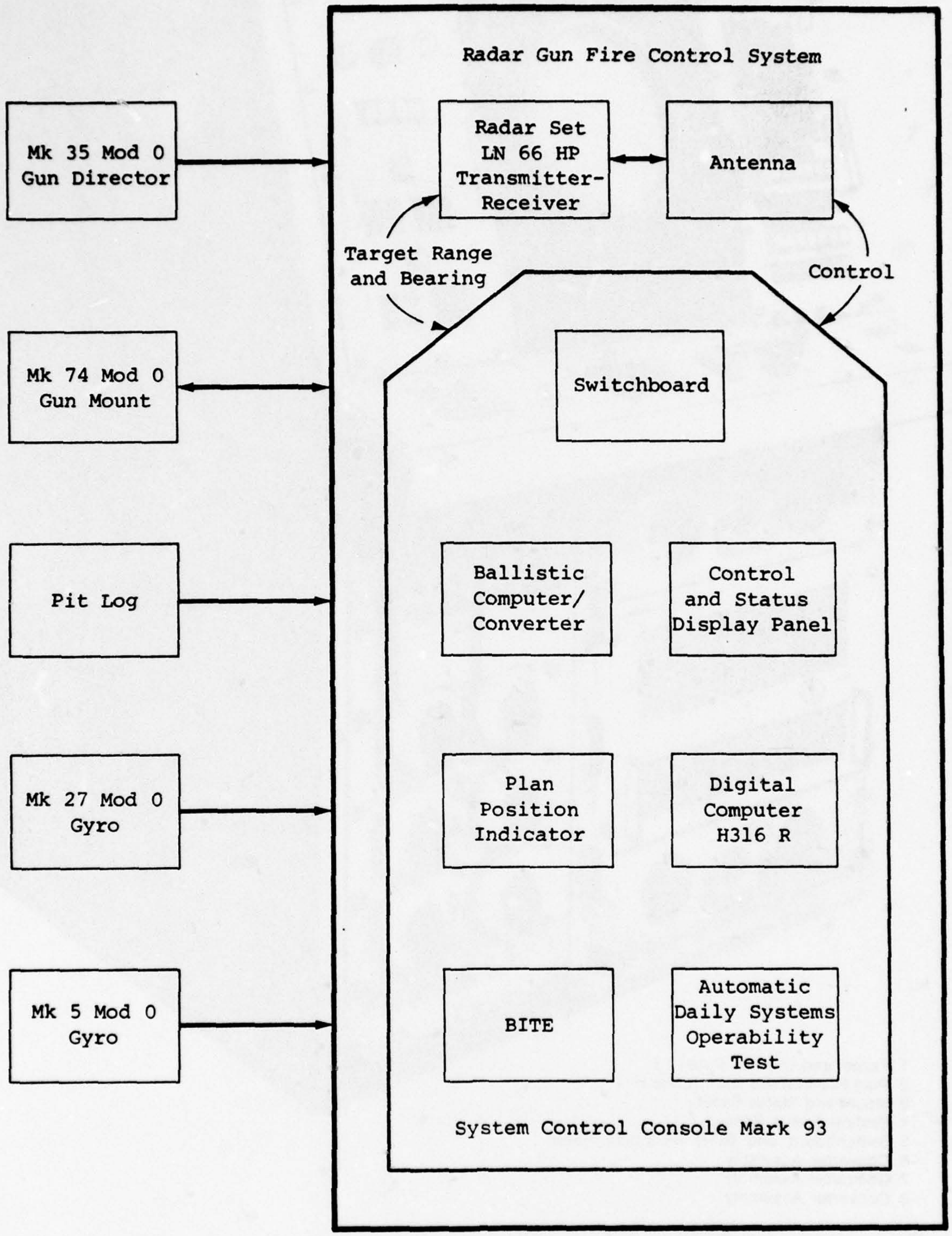
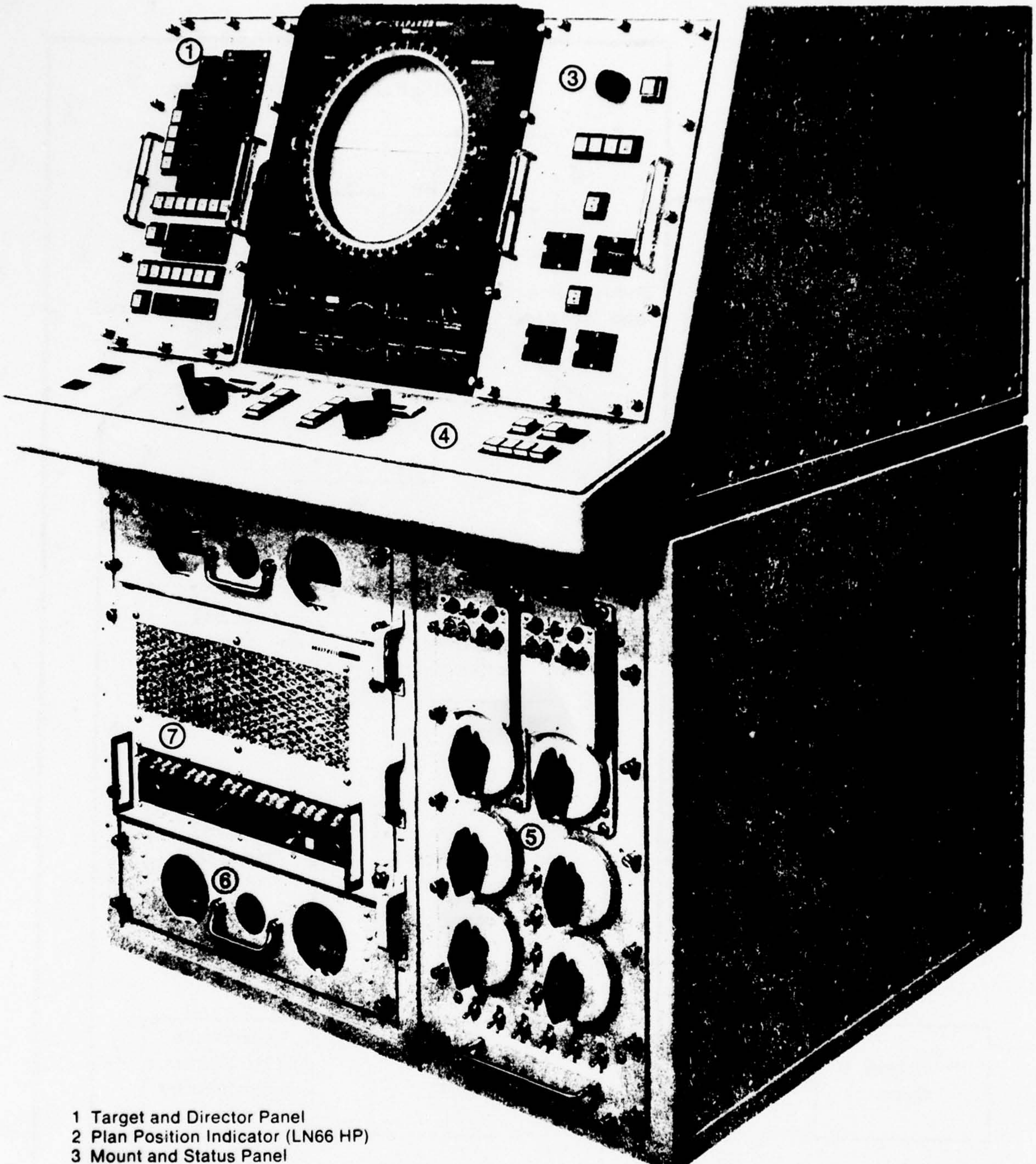


Figure 4. RGFCS MK 93 MOD 0 SIMPLIFIED BLOCK DIAGRAM



1 Target and Director Panel
2 Plan Position Indicator (LN66 HP)
3 Mount and Status Panel
4 System Status Panel
5 Switchboard and BITE Switching Panel
6 Converter Assembly
7 Computer Assembly
8 Converter Assembly

Figure 5. RGFCS SYSTEM CONTROL CONSOLE

Figure 6 illustrates the Mk 35 Mod 0 Gun Director System. The system shown here consists of two consoles and periscopes with a junction box. This is the two-director system installed in the prototype CPIC. Either console operator can control the single gun mount. Only director number one (forward) can control the xenon searchlight.

The EX 30 Mod 0 30mm Weapon System employs the Mk 5 Mod 0 gyro stabilizer and two frequency converters (power supplies). The Mk 5 Mod 0 gyro stabilizer provides pitch and roll data to the RGFCS for gun mount stabilization. The 1-kVA frequency converter supplies 3-phase 400-Hz power for the Mk 5 gyro. The 5-kVA converter supplies 1-phase 400-Hz power to the gun mount, the directors, and the RGFCS.

The weapon system can be operated in any of four modes:

- Navigation (NAV) - Radar and director are used for surveillance and navigation. The SCC computer conducts target-motion analysis (TMA) and determines designated target course and speed, and the range, bearing, and time of the closest point of approach (CPA) on the basis of radar/optical-supplied target data.
- Track-While-Scan (TWS) - Gun control orders are generated by the SCC computer, using radar range and radar bearing. Two TWS tracks can be handled simultaneously by the RGFCS.
- Split - Range data are supplied by the radar; azimuth and elevation data are supplied by the director. When the system is operated in the split mode, radar range, optical bearing, and optical elevation are used by the SCC computer to generate gun control orders. This mode, which is expected to be the primary engagement mode, also employs TWS operation.
- Optic - Optical target bearing and elevation are used to compute gun orders. The range necessary to resolve the fire control problem results from the director operator's manually entering target range at the director. The director operator can obtain range from the radar operator via sound power phones, or he can estimate it by means of the reticle in the periscope.

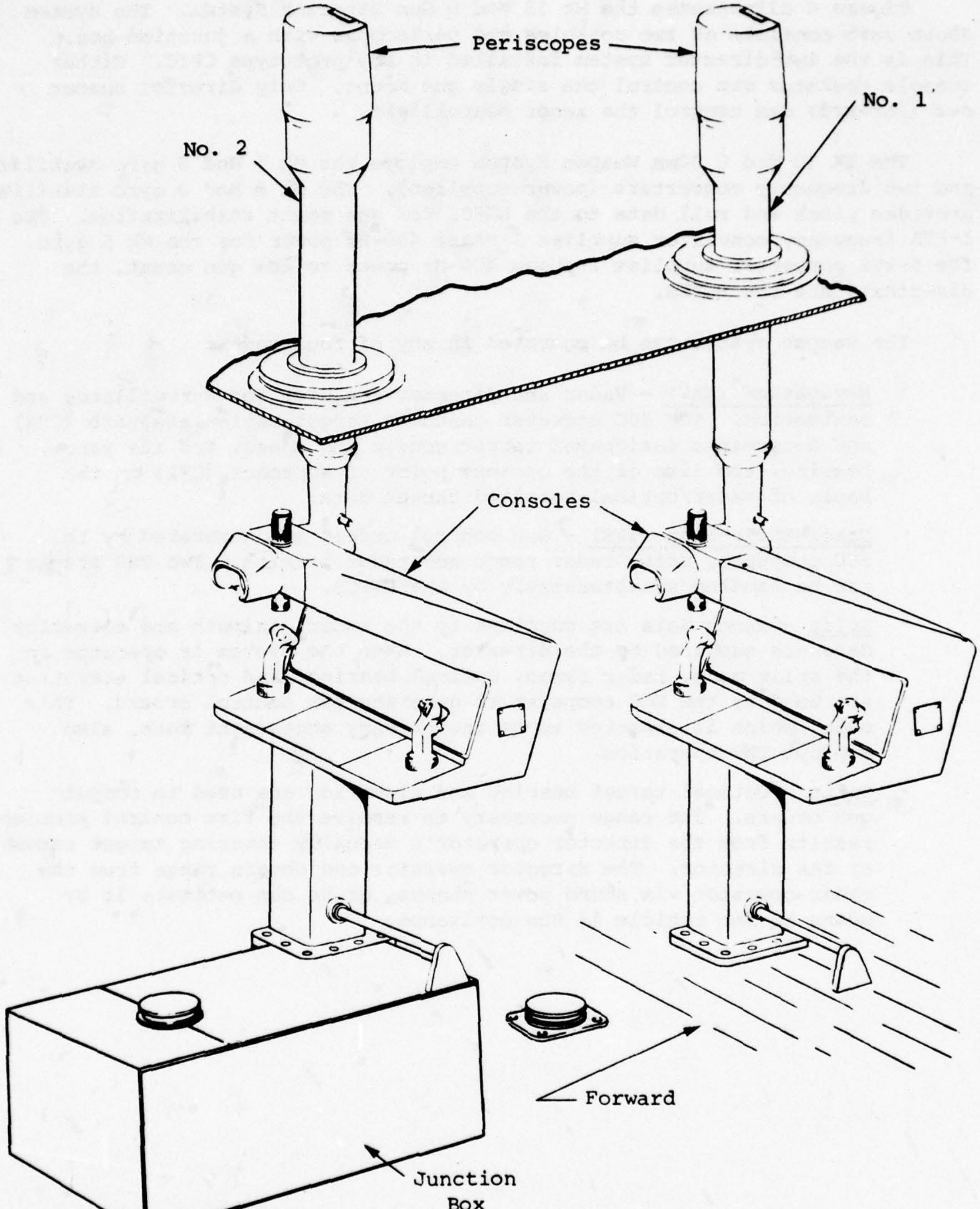


Figure 6. MK 35 MOD 0 GUN DIRECTOR

CHAPTER THREE

SUBSYSTEM DISCUSSIONS

3.1 MK 74 MOD O GUN MOUNT WITH TWIN HISPANO SUIZA TYPE 831 A/L 30MM GUNS

This section presents discussions of the mounts and the guns as separate entities.

3.1.1 Mk 74 Mod O Gun Mount

3.1.1.1 Subsystem Description

The Mk 74 Mod O gun mount is an electrically powered platform that supports two lightweight 30mm automatic weapons. The mount is capable of ±360 degree rotation in train and -15 to +80 degree rotation in elevation. Rotational velocities in either axis are 80 degrees per second, and accelerations are 80 degrees per second per second for either axis. Electrical and mechanical stops are provided for limiting train and elevation travel. Electric firing interrupts are provided to protect the hull and superstructure from self-inflicted gun-fire damage.

Included as part of the mount are a ready-service ammunition magazine and an ammunition feed system. The magazine, which is below deck, provides storage for approximately 1900 rounds of ammunition (950 for each gun).* The feed system comprises flexible chutes, magazine ammunition drive, ammunition booster drive, and feed control circuitry for each gun.

The mount is designed for both remote operation by the director subsystem and for local control from the on-mount operator's cabin either in a powered local mode or in a manual mode. For remote operations, all train and elevation data are provided to the mount by the RGFCS and the optical directors through the SCC. Gun fire can be initiated at either optical director.

The on-mount cabin is equipped with day and night sights for local-mode operation. A local control unit and an auxiliary control panel in the cabin provide display and control information for the mount operator. The train and elevation movements can also be powered by two hand cranks.

---

*Exact number of rounds in the modified magazine is not known at this time.

An on-mount battery currently provides electric power for the ammunition feed subsystem, the charging/cocking mechanism, and the solenoid-operated sear release in all operating modes. The battery is charged from ship's power when the guns are not being fired. The on-mount cabin is equipped with a heating and ventilation system to provide operator comfort. A de-icing subsystem for cold-weather operations is provided.

3.1.1.2 Discussion

The Mk 74 Mod 0 gun mount is being redesigned to accommodate the HS 831 A/L guns and to eliminate problems identified during testing. Present documentation does not reflect these changes. Therefore, a detailed analysis of the overall mount could not be performed. Elements that are being changed include the following:

- Magnetic clutch in elevation drive
- Grease seals on main train and elevation bearings
- Local-sight support brackets
- Blower for heater and air distribution
- Cabin-access-door hinges and fasteners
- Elevation spool and gun cradles
- Ammunition feed subsystem from magazine to belt-feeder
- Sponson
- Elevation servo drive
- Train and elevation drive electronics
- Elevation fire interrupter
- Equiliberator
- Gun fairings
- Gun control box

The following items are being added:

- Gun cocking/charging mechanism
- Firing solenoid
- Proximity switch
- Link alignment mechanism and oiler

The approach used in the preliminary review of the mount was first to develop a diagram that identified the functions required to train, elevate, and fire the guns, and then determine the hardware required to perform each of these functions. Because of numerous equipment changes, generic names were used for these equipments; they may differ slightly from those presented on the engineering drawings to be released. The diagram is presented in Figure 7. When this figure was completed, a critical-items list was developed

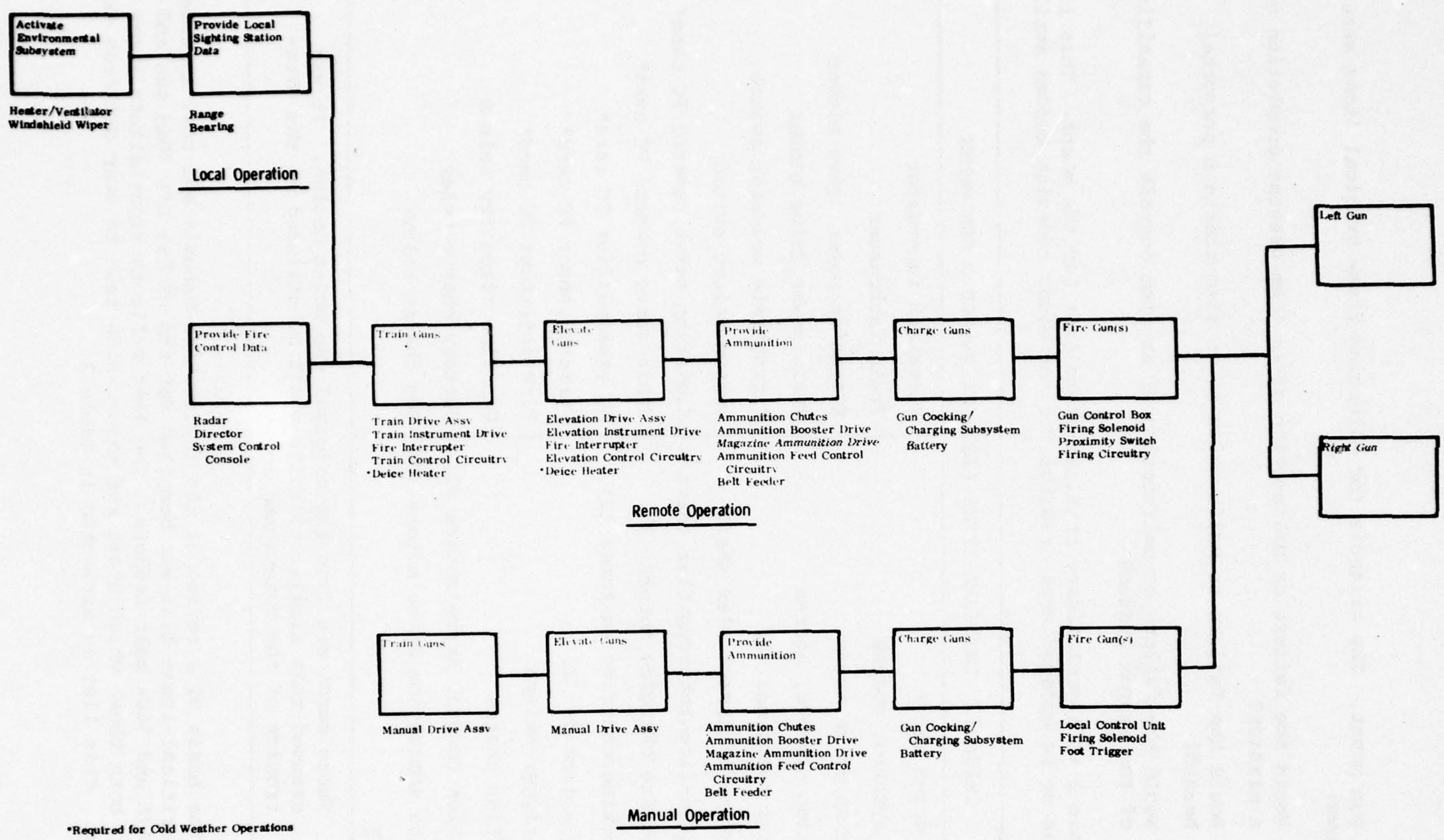


Figure 7. FUNCTIONAL DIAGRAM OF CPIC MOUNT AND GUNS

for the gun mount. The criteria for selecting these critical items were as follows:

- Would the failure or malfunction of an item prevent completion of a mission?
- Would the failure or malfunction of an item create a personnel hazard?
- Would the failure or malfunction of an item degrade the capabilities of the weapon system?

Table 1 is a preliminary critical-items list for the mount. This list will have to be updated when drawings for the mount redesign become available.

Table 1. CRITICAL-ITEMS LIST, MK 74 MOD O GUN MOUNT

Train drive motor	Elevation tachometer
Train synchro, coarse	Train tachometer
Elevation drive motor	Elevation power drive blower
Elevation synchro, coarse	Train power drive blower
Magnetic couplings (2)	Firing-rate selector switch
Train-fire-interrupt flex shaft	Weapon select switch
Elevation-fire-interrupt flex shaft	Elevation servo control PC card*
Gun cocking/charging motors (2)	Train servo control PC card*
Gun cocking/charging switches (2)	AC preamplifier PC card*
Firing solenoids (2)	Current-sensor PC card*
Foot trigger switch	Fire-interrupt PC card*
Ammunition chutes	Gun fire circuitry relays
Ammunition booster drive motors (2)	Battery charge relay
Magazine ammunition drive motors (2)	Gun charge relays
Battery	

*Note: These cards are from the original gun mount design. It was assumed that similar circuits would be utilized in the electronics of the redesigned mount.

On the basis of a review of the instruction manuals and test information, a critical-items list was compiled for the HS 831 A/L 30mm gun and the HS 567A and 568A belt feeders. The list reflects high-failure items, including both those which break and those which tend to wear out from gun operation. This list is presented in Table 2.

Table 2. CRITICAL-ITEMS LIST, HS 831 A/L 30MM GUN	
HS 831 A/L Guns	
Barrel assembly	Extractor
Gas ports (2)	Extractor spring
Sear buffer springs (3)	Extractor pivot pin
Sear block slide	Breech block lock
Sear	Firing pin
Sear pin	Firing pin springs (2)
Trigger unit (complete)	Inertia pin springs (2)
Breech unlocking push rods (2)	Ejector
Return spring assembly	Ejector springs (3)
Belt Feeder, HS Type 567A/568A	
Torsion bar (part number 245.434)	Extractor lever, forward
Extraction level springs (2)	Extractor lever, rear
Pulling springs (3)	Torsion bar (part number 245.746)
Last-round spring assembly	

3.1.1.3 Reliability and Maintainability

Both on-shore system-integration tests (OSSIT) and at-sea tests were conducted on the mount. The total test time accumulated was 108 hours. During the tests a total of 12 failures occurred. Only one of these failures was considered applicable in the calculation of a point estimate of the mount's reliability. Redesign should prevent the recurrence of seven of the failures. Two failures were caused by assembly and installation errors. One failure was caused by a maintenance error, and one was judged to be not critical to mount operation. A summary of these failures and their disposition is presented in Table 3. Appendix B summarizes CPIC weapon system failures.

Assuming that the failure characteristics of the systems in this report, other than the guns, can be represented by the mathematical model

$$R(t) = e^{-\lambda t} \tag{1}$$

where

$R(t)$ = reliability (expected percent of success) in the time interval, t

t = time interval

e = Naperian base 2.71828

λ = failure rate

then

$$\lambda = 1/\theta \tag{2}$$

where

θ = mean time between failures (MTBF)

By definition

MTBF = the total measured functioning time of a population divided by the total number of failures within the population during the measured period

or

$$\text{MTBF} = \frac{\text{Total Operating Time}}{\text{Total Number of Failures}} \tag{3}$$

If the redesign is well conceived and executed, then the point estimate of the reliability of the mount for four hours' operation could go as high as 0.9636.

The four hours of operation is an estimate of the time the mount would be in use during a 60-hour mission.

Maintainability of the guns and gun mount is discussed in Section 3.1.2.3.

3.1.2 HS 831 A/L Gun

3.1.2.1 Subsystem Description

The guns are Hispano Suiza Type 831 A/L 30mm automatic weapons. The belt feeders are Hispano Suiza Type 567A (left-hand) and Type 568A (right-hand). The maximum firing rate of each gun is approximately 600 rounds per minute. Controls permit the selection of guns and firing rate: single shot, 150 rounds per minute, or maximum rate -- with left gun, right gun, or both guns.

A motor-driven charger/cocking mechanism initiates the operation of each gun. This mechanism cocks the weapon and causes the belt feeder to position the first round in the gun chamber for firing. Firing is accom-

Table 3. SUMMARY OF MK 74 MOD 0 MOUNT FAILURE INFORMATION

Subsystem/Equipment	Casualty Description	Test Location	Remarks and Description
Train Drive Mechanism	Excessive bearing friction	OSSIT	Installation error
	Magnetic clutch problem	OSSIT	Design change
Ammunition Feed	Booster motor miswired	OSSIT	Assembly error
	Burned-out booster motor	OSSIT	Low voltage caused booster motor to burn out at 108 operating hours (failure rate is 9,259 failures per million hours)
Electronic Components	Power amplifier and supply	OSSIT	Design change
	Power amplifier	OSSIT	Design change
	Power amplifier	OSSIT	Design change
Battery (NICAD)	Discharged	OSSIT	Maintenance error
Cabin	Door fasteners broke	OSSIT	Not critical
	Broken door hinges	At sea	Design change
Local Sighting Station	Support bolts sheared	At sea	Design change
De-Ice	Circuit breaker opened when de-ice circuit was energized	At sea	Design change

plished by a solenoid that actuates a mechanical trigger unit. Recoil of the gun removes the fired casing, recocks the weapon, and operates the belt feeder. The belt feeder de-links ammunition and positions the next live round in the gun chamber. This is a recurring sequence of events during gun operation.

3.1.2.2 Discussion

The following series of test-firing reports on the HS 831 30mm guns was reviewed and evaluated to estimate the reliability of the weapon:

- Component Durability Test Firing of the 30mm HS-831 (SL) Automatic Cannon, Fifth Phase of Firing, Report Number W50/67, dated 28 September 1967
- Component Durability Report (first follow-up test) of the 30mm HS-831 (SLM) Automatic Cannon Testing Station 91, Report Number 52/71, dated 12/5/71
- Comparison Test Firing to Determine the Barrel Life of the 30mm HS-831 (SL) Automatic Cannon, Fourth Phase of Firing, Report Number W15/67

- Mini-Mod Firing Tests conducted at NWL/D during 8 November 1973 to 8 January 1974
- Summary of Emerson Firings through 21 June 1974

From data contained in these reports, the probability of successfully accomplishing a 500-round engagement over a 15- to 20-minute time period was calculated. It was assumed that the guns were firing in parallel, that either gun could complete firing the 500 rounds if one failed, that during any given burst no more than 40 rounds per gun would be fired, that there would be a one- to two-minute pause between bursts, and that stoppages clearable by recharging the guns would not constitute a failure.

3.1.2.3 Reliability and Maintainability

The point estimate for the probability of success under these conditions is

$$R_s = (R_{250})^2 + 500\, R_{500}\, (1 - R_1)^*$$

where

R_{250} is the probability of one gun firing 250 rounds

R_{500} is the probability of one gun firing 500 rounds

R_1 is the probability of one gun firing 1 round

Then

$$R_s = 0.815$$

This equation represents the probability of firing 500 rounds without failure from guns in a like-new operating condition. A constant failure rate was assumed for these guns.

It appears that the ROKN will be capable of performing adequate preventive and corrective maintenance on the gun mount and the HS 831 A/L guns. The condition of present ROKN gun systems, as observed during the trip to Korea on 3-14 June 1974, indicates that excellent preventive maintenance is being performed. On-board corrective-maintenance capability is limited by the lack of required skill levels; thus shipyard assistance is required for most corrective maintenance. The shore facilities for gun system corrective maintenance were assessed as adequate to maintain the 30mm gun if sufficient training is provided. The present plan for the crew to perform only preventive maintenance while in port is consistent with the present ROKN gun-maintenance program. However, the 30mm HS-831 A/L gun will require greater attention to detail and a closely monitored preventive-maintenance program to ensure gun availability and reliability. In addition, the gun mount contains the feed system, which, because it is a compact system

*The derivation of this equation is given in Appendix A.

cycling at a high rate, will also require a well developed and closely monitored preventive-maintenance program.

The nature of the craft and its mission profile precludes performing any corrective maintenance while under way except that which is absolutely essential. The replacement of gun barrels and similar actions would be within the crew's capability, but in-depth troubleshooting and replacement of electrical or electronic components in the mount are beyond expected operational maintenance capability. It is essential, therefore, that the craft depart on any mission with an operating mount and guns that have been maintained at a level that will ensure the best possible chance of completing the mission without gun failure.

Interim Maintenance Index Pages (MIP) and Maintenance Requirements Cards (MRC) were reviewed. These pages and cards cover the gun mount and feed system, but no cards are available for the guns themselves. In addition, the MRCs for the mount are to be changed to reflect the modification made to accommodate the HS 831 A/L guns. Since maintenance procedures and documentation provided with the craft will be major factors in the maintainability of the gun system, it is essential that the updated MRCs for the mount and a complete set of MRCs for the guns be available as soon as possible.

3.2 MK 35 MOD O GUN DIRECTOR

3.2.1 Subsystem Description

The Mk 35 Mod 0 gun director installed in the CPIC consists of two periscope director assemblies, two console assemblies, and one junction box. The system is located in the pilot house, with the periscopes projecting through the roof; periscope director number one is forward, and number two is aft (see Figure 6). The director operator can select and fire the guns, and direct and select operating modes for the searchlight. Either director is capable of controlling one or two twin 30mm Mk 74 Mod 0 gun mounts. The directors can be operated in any of the four modes described in Chapter Two. The subsystem characteristics are as follows:

- Train - Unlimited rotation
- Elevation - +80° -30°
- Magnification - Low power, 1.3 X; high power, 5.2 X
- Field of View - Low Power, 32°; high power, 8°
- Night Viewing - Image intensifier with four levels of filter available
- Periscope Assembly
    - •• Weight - 455 pounds
    - •• Length - 93 inches
    - •• Diameter - 17-1/2 inches

3.2.2 Discussion

An investigation of the system based on available documentation and discussion with Navy and contractor personnel has identified a number of areas of concern. These areas should be considered as possible operational and maintenance problem areas.

The periscope optical/mechanical portion of the director appears to merit special attention at this time since failure predictions for the electrical portions of the system have already been made. These predictions are discussed in Section 3.2.3.

The periscope assembly will present maintenance, repair, and overhaul problems, some of which may be alleviated in the production models through modifications or design changes.

The periscope is pressurized with dry nitrogen gas. The pressurized section contains a number of electrical components in addition to optical and mechanical components. The manufacturer recommends purging the periscope with dry nitrogen gas for 30 minutes each time the periscope seal is broken. The nitrogen-gas inlet valve assembly is located at the base of the periscope inside the pilot house, while the bleed screw is at the head of the periscope outside the pilot house. This configuration, coupled with the purge-time requirements and the compactness of the optical and mechanical system, appears to add significantly to the MTTR of the periscope. Removal of the electrical components from within the periscope, as recommended by the Kollmorgen Corporation, may alleviate the problem, but, since some components cannot be removed and the mechanical and optical components would remain, this action may not be warranted. Elimination of the dry-nitrogen pressurization requirement appears to be desirable from a maintenance standpoint. The seriousness of any fogging or other problems associated with eliminating the nitrogen pressurization must be determined before any action is taken in this area. If the dry-nitrogen pressurization feature is retained, a pressure gauge should be permanently installed in the periscope to monitor the gas pressure.

One recorded failure (slipped derotation synchro) brought to light the need for special tools to work on components inside the periscope. This problem has been solved by changing the type of screw used to retain the synchro, but assurance must be provided that any other special tools required for inspection or repair of the periscope will be supplied with the system.

Specifications for the production models should include the requirement for providing alignment marks or points on the assembly wherever mechanical adjustments must be made to facilitate installation and alignment.

The two periscope gyros, located in the head of the periscope, have a high predicted failure rate, and their replacement will be difficult. Because of their location, it will be necessary to break a seal and lift the shroud assembly from the periscope for removal. Removal of the shroud may require a lightweight lifting device (crane, tripod, etc.), and provisions

should be made for mounting such a device. A lifting-bolt insert is available in the shroud. The manufacturer recommends removing the shroud only at ambient temperatures of 50°F or greater. Protection of the exposed (outside the pilot house) portion of the periscope from moisture will also be required. Removal of the entire periscope assembly to perform maintenance is undesirable, because of the size and weight of the unit and the probable requirement to perform battery alignment after the periscope is reinstalled.

It would be worthwhile to investigate the possibility of eliminating the periscope gyros and utilizing the ship's pitch and roll gyro (Mk 5 Mod 0) to supply stabilization, or using computer-aided tracking to eliminate the need for gyros in the periscope.

The night image intensifier tube is located in the pressurized portion of the periscope assembly. To remove this tube, it is necessary to depressurize the unit. The possibility of relocating the image intensifier outside the pressurized section should be considered.

The present system has a protective shutter to protect the image intensifier from gun flash. This shutter is activated by the firing key on the console. No provisions are made for a cross-connect of this shutter to protect the image intensifier from gun flash if the gun is fired by the second console operator. It may be advisable to actuate the shutter only when the gun-to-periscope alignment is within a specified limit. In addition, it should be determined whether reflected light from the search light will interfere with the image intensifier's operation. This situation can occur when director number one is using the search light and director number two is employing the image-intensifier mode.

Some method of clearing spray and other contaminants from the outer surface of the periscope window will be necessary when the craft is under way. Rain may also have to be cleared. Windshield wipers do not appear to be practical, since they can scratch the glass, especially if there is a salt residue on the glass. There is no fresh water currently available at the periscope head for flushing the windows. Consideration should be given to the possibility of using a single-surface window (vs. two surfaces currently used), with a spinning port to clear rain and spray, and making provisions for fresh-water flushing of the window.

Existing battery-alignment procedures (NAVORD OD 45528) recommend using director number one as the reference element. Since the optical director may be removed or exchanged during maintenance and the director is not difficult to align, it appears that a more logical method of battery alignment in the prototype craft with a single mount would be to use the mount as a reference.

The console assembly does not appear to present any unusual maintenance problems, but the following items should be considered:

- All of the control switches are physically identical, which requires the operator to look at the panel to perform routine functions such as search-light operation. The switches should have unique shapes to assist the operator.

- Search-light control circuits are available at both consoles, but only director number one can control the search light. Consideration should be given to permitting control of the search light by either console on a first-come basis. This would provide redundancy and improve the versatility of the system.
- Both prototype consoles have experienced failures in the lighting dimmer circuits. This appears to be a design problem, and it should be corrected prior to production.
- The present magazine low-limit bypass switch (MAG OVRD) bypasses all magazines. This is not a problem on a single-mount installation, but if future craft are developed with two mounts, a method of alerting an operator that the magazine low-limit stop has been overridden by the other console operator will be necessary.
- Search-light train limits and stops should be displayed or otherwise indicated to the console operator.

The periscope has no horizon reference; thus locating the horizon on a dark night would be difficult. An artificial horizon should be provided.

The principal problem associated with the junction box appears to be its location and access for testing and repair. Although no underway maintenance is planned, any work on the box will require evacuation of both director consoles.

3.2.3 Reliability and Maintainability

The Mk 35 director is a unique combination of electronic, optical, and mechanical subassemblies; as such, it will present a unique set of requirements to the user.

Total system reliability and maintainability analysis is hampered by the inability to predict mechanical failure rates accurately. The heart of the Mk 35 is the periscope assembly, which is primarily an optical/mechanical device.

Preliminary data on failures of the Mk 35 system both in the on-shore system integration tests (OSSIT) and the at-sea testing over the period November 1972 through February 1974 indicate a total of ten failures, five of which were mechanical/optical.

Table 4 is a detailed failure breakdown of the Mk 35 Mod 0 for this period. Appendix B summarizes CPIC weapon system failure data.

The Kollmorgen Corporation Gun Director Mk 35 Mod 0 Reliability and Maintainability Analysis, Report Number ER 877.10, Revision A, of 1 January 1974, was reviewed. The report is based on predicted electrical failures and appears to be reasonable. As discussed in Section 3.2.3, the Mk 35 may experience as many mechanical/optical failures as electrical failures,

Table 4. MK 35 MOD 0 FAILURE BREAKDOWN

Number	Subsystem	Failure	Date	Remarks	Mechanical or Electrical (M or E)
1	Optic #1	Elevation binding	11/16/72	Installation error	M
2	Optic #1	Night-day handle	12/18/72	*	M
3	Optic #1	Window cracked	12/23/72	Design deficiency; changed	M
4	Director #2	On/NAV switch	1/17/73	*	E
5	Director #2	Bad resistor/broken connector	2/18/73	*	E
6	Director #2	Dimmer circuit potentiometer	3/6/73	Not critical	E
7	Optic #1	Leaking window	6/19/73	Excessive environmental conditions	M
8	Optic #2	Slipped derotation synchro	10/25/73	Not critical	M
9	Director #2	Elevation amplifier MA-1	1/16/74	*	E
10	Director #1	Dimmer circuit transistors	11/13/73	Not critical	E

*Counted as a failure.

or more. No estimate of nonelectrical failure rates is considered in the cited report, and it is emphasized here that the total system MTBF will be somewhat lower than predicted in the report.

In predicting failure rates for the two console assemblies, it was assumed that they were identical. This is true from a mechanical standpoint. However, in the prototype two-console system, there are nine searchlight function switches and indicators in both consoles, but they are employed only in director number one. This results in the number two director's having a slightly better MTBF than number one. The effect is considered too slight to justify changing the prediction.

The MTTR predictions for items located in the pressurized portion of the periscope (requiring opening, resealing, purging, and repressurizing the periscope) are the same for both organizational-level and depot-level maintenance. It is questionable if organizational-level maintenance will be performed on the pressurized section of the periscope. However, if organizational maintenance is required, the MTTR of the periscope will probably be significantly longer than at the depot level because of personnel and equipment limitations. The depth of periscope maintenance to be performed at the organizational level is an area worthy of investigation, since it appears that it may not be practical to work on items in the pressurized portion of the periscope at the organizational level.

The Kollmorgen analysis resulted in a predicted MTBF of 419 hours for a single-director system and an MTBF of 629 hours for a two-director system. Analysis of the limited failure data available (see Table 4) at this time resulted in a best-case MTBF of 459 hours for a single-director system. This is equivalent to a mission reliability of 0.985 for a 60-hour mission with two directors in parallel. These limited data include both electrical and mechanical failures, while only the electrical-failure data were used for the predicted MTBF.

The components of the Mk 35 Mod 0 that exhibit a predicted failure rate of 50 failures per million hours or greater are as follows:

- Gyroscope, P/N 877B035858 (two each located in the elevation and azimuth drive assembly of the periscope)
- Relay, P/N 877B036169 (six each in the power control module assembly of the junction box)
- DC Servo Amplifier, P/N 877B036276 (console -- panel assembly)
- Relay, P/N 877C036194 (console -- shroud drive and radar optical range assembly)

No component failure in the Mk 35 would make the weapon system inoperable in all modes of system operation.

As discussed in the Kollmorgen analysis, the predicted reliability of the system could be improved by upgrading the integrated circuits (ICs) from MIL-STD-883 Class D parts to Class B. This would increase the cost of the system. In addition, it has been pointed out that much of the director is optical/mechanical, and this is not addressed in the anlysis. Of the ten recorded failures that occurred during test, only one was due to an IC (elevation amplifier MA-1), and five of the failures were mechanical. Cost trade-offs involved in upgrading the ICs should be analyzed prior to any upgrading decision.

Maintainability of the director may present a problem for that portion of the system within the periscope assembly. Whether or not the ROKN should establish optical maintenance facilities for the periscope assembly will depend to some extent on the total number of CPICs to be operated and maintained. The recommended interim procedure is to stock a complete spare periscope assembly for replacement and return the defective periscope to the manufacturer for repair. Preventive-maintenance procedures for the Mk 35 as set forth in the interim MRCs should present no problems.

3.3 MK 93 MOD 0 RADAR GUN FIRE CONTROL SYSTEM (RGFCS)

3.3.1 Subsystem Description

As configured aboard the CPIC, the Radar Gun Fire Control System Mk 93 Mod 0 consists of a System Control Console (SCC), including a Honey-

well H316R computer, and a KAAR Electronics Corporation LN66HP commercial radar set (see Figure 4). Inputs from Gyro-Compass Mk 27 Mod 1, Gyro Stabilizer Mk 5 Mod 0, and an electromagnetic ship's log system are required for solution of the fire control problem. In addition, manual input of estimated wind speed and direction is required since there is no wind-sensing device aboard the CPIC.

The system is capable of the following functions:

- Detecting and displaying targets through 360° of azimuth and ranges up to 36 miles if they are within the radar horizon.
- Simultaneously tracking two targets at ranges up to 10 miles, using two Track-While-Scan (TWS) modules within the SCC.
- Performing Target Motion Analysis (TMA) on four targets, utilizing input data on two simultaneous targets from the LN66HR Radar and one target from each Mk 35 Mod 0 Director.

The RGFCS may operate in any one of the four modes described in Chapter Two, depending on the source of target data entering the system computer. In addition, the system is capable of functioning in two "coast" modes:

- Director Coast - Prior optical target position and rate information results in the generation of an appropriate slew rate to position the director optics in the event the target is lost optically. The guns may be fired in this mode. In the event the target is regained, the original mode of operation may be restored.
- RGFCS Coast - Target position and rate data prior to loss of the TWS target track result in the SCC computer's automatically maintaining the target track and displaying it on the Plan Position Indicator (PPI) for three sweeps (approximately 8 seconds) after target loss. The guns may be fired in this mode. In the event the target is not regained after three sweeps, the TWS symbol will disappear from the PPI and the NO TRACK indicator will light on the SCC. Should the target be regained, the original mode of operation can be restored.

3.3.2 LN66HP Radar

The LN66HP Radar is an off-the-shelf marine radar manufactured by KAAR Electronics Corporation, modified to make it electronically compatible with the RGFCS TWS capability. The radar set consists of four basic elements:

- Antenna Unit - radiates RF pulses received from the transmitter into space. The element also receives signals reflected from the target for transmission back to the receiver.

- Transmitter/Receiver - the unit's magnetron, operating at 9375 ± 30 MHz, generates 75-kW peak power output pulses of RF energy for radiation by the antenna with the following characteristics:

Range (Miles)	PRF (pps)	Pulse Width (Seconds)	Average Power Output (W)
½, 1½, 3	1000	0.1	6.5 (minimum)
12, 24, 36	500	1.0	32.5 (minimum)

The T/R unit also receives and detects reflected target signals. Power supplies, internal to the T/R unit, generate the necessary voltages for operation.

- Display Unit - provides the SCC operator a visual presentation of reflected target signals and houses all of the controls and switches necessary to operate the LN66HP Radar. It is an integral part of the SCC.
- Power Supply - separate transistorized regulator and inverter circuits supply the voltages required for operation of the display and antenna units. The supply requires an input of ±28 Vdc.

3.3.2.1 Radar Reliability

The LN66HP Radar for the CPIC was in operation undergoing On-Shore System Integration Test (OSSIT) for 1234 hours and At-Sea Trials for 589 hours, a total of 1823 hours.* The one radar failure occurred at sea in the T/R unit when the pulse trigger was not disabled during the switching cycle from narrow to wide pulse, causing the relay contact to become welded (see Appendix B).

An MTBF of 1823 hours is established for the LN66HP Radar, and λ equals 548.546×10^{-6} failures per hour. It is emphasized that the majority of operational hours were accumulated under nearly ideal operating conditions -- the OSSIT. The one failure experienced by the radar occurred during the 589 hours of At-Sea Trials. For this number of operating hours in the environment in which it will be operated, the MTBF is 589 hours, and λ is 1698×10^{-6} failures per hour. From the total number of operating hours accumulated during OSSIT and At-Sea Trials, i.e., MTBF

*Data supplied by NWL/D.

= 1823 hours, the probability of the radar's completing a 60-hour mission (t = 60 hours) without a failure is found to be

$$R(60) = 0.9676$$

Considering only the hours of operation during At-Sea Trials (MTBF = 589 hours), we obtain

$$R(60) = 0.9032$$

A summary of LN66HP Radar reliability for several mission durations and MTBFs is shown in Table 5.

Table 5. LN66HP RADAR RELIABILITY

Mission Length, t hours	Reliability, R(t)	
	MTBF = 1823 hours $\lambda = 548.546 \times 10^{-6}$	MTBF = 589 hours $\lambda = 1698 \times 10^{-6}$
0	1	1
15	0.9918	0.9749
30	0.9837	0.9503
45	0.9756	0.9264
60	0.9676	0.9032

Some additional data on the LN66HP Radar, as employed in the Navy LAMPS Program, were provided to ARINC Research by NOSL. The data were in the form of Reports 3M006, dated 13 April 1974, for the SH-2F and SH-2D type aircraft. Analysis of these data indicates that for an accumulated 8354 flight hours in 1973, considering all radar system failures, the failure rate for the LN66HP Radar in an airborne environment is 40475×10^{-6} failures per flight hour and the MTBF is 24.71 hours.

The difference between this MTBF and that determined earlier for the radar as used in CPIC may be attributable to differences in (1) quality of data analyzed, (2) physical construction of the radar sets, and (3) the operational environment. The LN66HP installed in CPIC differs from that in the LAMPS installation. Differences in the antenna system, display unit, and other subsystems could not be completely identified because of the lack of documentation. The LAMPS operational environment differs from that of the CPIC in a number of ways, some of which are:

- <u>Mission Operate Times</u> - LAMPS missions are normally less than four hours, while the CPIC missions will be 15 to 60 hours.

- Temperature Ranges - LAMPS radar can experience more rapid changes in ambient temperature because of flight profiles.
- Operating Procedures - CPIC can normally be expected to place radar in standby and to be on craft power for a much longer period prior to radar operate than the LAMPS, which will not have craft power until after the helicopter is started immediately prior to flight.

Efforts to obtain additional amplifying or substantiating data through NAVAIRSYSCOM, the 3M System, and the Government and Industry Data Exchange Program (GIDEP) were unsuccessful.

Little concrete information regarding potential failure modes can be extrapolated from the radar test data of one failure in 1823 total hours of radar system operation. However, parts usage information supplied to NAVAIRSYSCOM by Kaman Aerospace Corporation, Bloomfield, Connecticut, and forwarded to ARINC Research by NOSL indicates potential problems in the power supply. The number of power transistors replaced in the power supply is shown in Table 6. (The additional part-replacement data provided are summarized in Table 6, reflecting only those parts in an element that required ten or more replacements. It is noted that the given information does not include a time frame, so that frequency of replacement cannot be extrapolated -- only the number of replacements.)

Table 6. SUMMARY OF PARTS REPLACED

Element	Part	Number Replaced
Power Supply	Power Transistors	104
	SP-2274-2	104
	2N-4899	20
	2N-4910	16
Display Unit	PRF PCB	23
	Lamp Number 350	12
	VRM PCB	11
	Video PCB	10
T/R Unit	Pulse Transformer	28
Antenna	Motor	13

The LAMPS failure data were not directly integrated with the CPIC data, because of the foregoing considerations. The LAMPS data are presented here as a possible indication of areas that should be pursued if similar failure patterns occur in CPIC as additional operational time is accrued.

3.3.2.2 Radar Maintainability

The maintenance philosophy for the LN66HP Radar aboard the CPIC has not been established, although it is envisioned that there will be three levels of maintenance, with emphasis on the intermediate and depot levels.

The LN66HP radar system as used in the LAMPS program is not dependent on depot-level maintenance, since the system is totally supported by the Intermediate Maintenance Activity. In this environment, the system is supported by the kit concept, and printed circuit boards are considered as consumable since they are low-cost items and it is uneconomical to repair them.

A commercial-style manual, "Maintenance Instructions with Illustrated Parts Breakdown for LN66HP Radar Set", NAVAIR 16-45-1691, was made available to ARINC Research by NOSL. Some discrepancies between the parts lists and the schematic diagrams were noted. Two examples are:

- Klystron 2K25 is shown in the Group Assembly Parts List, page 4-11, and Receiver Circuit Schematic, page 5-48/49, but not in the Numerical Index or Reference Designation List.
- Power Supply Resistors R208, R217, and R225 are not listed in the Reference Designation List.

Since modifications have been made to the radar to ensure compatibility with SCC TWS, it is recommended that a maintenance manual for the CPIC LN66HP Radar Set be developed that accurately reflects the parts breakdown and schematic for the CPIC installation.

ARINC Research has insufficient data to develop a list of LN66HP Radar components and lowest-level assemblies that exhibit a failure rate of 50 failures per million hours of operation or greater. Failure of the radar subsystem will not make the EX 30 Mod 0 30mm Lightweight Gun System inoperative in the optic mode. It is recommended, however, that efforts be continued to obtain amplifying data on the high number of power transistors replaced in the LAMPS radar power supply. Until the data can be verified and an actual rate determined, these power transistors should be considered as potentially high-failure items.

3.3.3 System Control Console (SCC)

The major subsystem of the GFCS is the SCC. It provides CPIC with the information capabilities of a surface Combat Information Center (CIC). Computed target data, generated in and displayed on the SCC, include the following:

- Target bearing
- Target range
- Target course

- Target speed
- Range, bearing, and time of closest point of approach (CPA)

The SCC is composed of 11 assemblies designated A01 to A11 (assembly location within the SCC is depicted in Figure 5):

- A01 - Target and Director Assembly. A01 houses the digital logic cards that constitute the Track-While-Scan and Input/Output control circuits. Its front panel holds the controls, readouts, and switches for control of the interface with the directors and display of own-ship data, target data, and director data.
- A02 - Plan Position Indicator (PPI) Assembly. A02 provides the SCC operator a visual presentation of all radar targets acquired by the LN66HP Radar. It houses all of the controls and switches necessary to operate the LN66HP Radar.
- A03 - True North Assembly. A03 houses a torqsyn and a synchro transmitter (MAGSLIP), which, in combination with the control differential transmitter (CDX) in the radar antenna, keeps the PPI display oriented so that all target bearings are true bearings.
- A04 - Mount and Status Assembly. A04 contains the test and control panel and those analog and digital circuits necessary for SCC interface with the LN66HP Radar. The front-panel controls and indicators provide control of SCC panel illumination and capability for monitoring the operational status of the computer, own-ship's sensors, gun mounts, and Built-In Test Equipment (BITE) switches.
- A05 - System Status Assembly. A05 contains the controls and indicators required for control of power to the SCC, computer, and radar. Included are those controls, indicators, and circuits required to accomplish the following:
  - Input radar range and bearing and wind direction and velocity information into the computer
  - Designate and assign TWS circuits
  - Display TWS and radar status
  - Control tracking windows and false-target position
  - Display relative bearing and range of false target
- A06 - Upper Converter Assembly. A06 provides the interface for all synchro and analog signals between the SCC and director one and for synchro control signals from the SCC to mount one. The assembly also provides synchro-to-digital conversion for ship roll and pitch.
- A07 - Computer Assembly. A07 is programmed to solve the fire control problem. It uses the data provided to conduct a target-motion analysis and to generate gun orders.

- A08 - Lower Converter Assembly. A08 provides the interface for all synchro and analog signals between the SCC and director two, and for synchro control signals from the SCC to mount two. It also provides synchro-to-digital conversion for own-ship heading and antenna position.
- A09 - Switchboard and Power Supply Assembly. A09 contains two dc power supplies, BITE switches, switchboard switches, and the encoding relay matrix. It provides power within the SCC for logic, amplifier, and converter power.
- A10 - Right Rear Connector Assembly. A10 contains RFI filters and input/output connectors.
- A11 - Left Rear Connector Assembly. A11 contains input/output connectors.

3.3.3.1 SCC Reliability

The System Control Console (SCC) was in operation undergoing On-Shore System Integration Test for 1234 hours and At-Sea Trials for 589 hours -- a total of 1823 hours.* An additional 149 hours' operation time was accumulated on the H316R Computer, Assembly A07, while programming operations and tests were being conducted during the At-Sea Trials. Consequently, Assembly A07 has an accumulated 1972 hours under test.

SCC casualties are itemized in Appendix B. Assembly casualties considered as failures are described as follows:

- A01 - Target and Director Assembly. The target-motion analysis switch for director two failed on 16 July 1973 during OSSIT.
- A04 - Mount and Status Assembly. A TWS threshold potentiometer failed during OSSIT on 30 May 1973.
- A06 - Upper Converter Assembly. A high-speed synchro-to-digital converter failed during At-Sea Trials, causing erratic gun orders to be generated.
- A07 - Computer Assembly. During OSSIT, there were three card failures (line driver card, 23 June 1973; priority PAC card, 25 June 1973; and M-register card, 11 July 1973) and four intermittent casualties of more than four hours' duration in the period 4 April through 3 July 1973. Two card failures (PC card CMO 22, 25 October 1973; PC card TG335, 30 October 1973) occurred during At-Sea Trials, preventing the input and output of data to and from the computer.

Assembly and SCC failure rates and MTBFs were determined by using Equations 1 through 3, Subsection 3.3.2.1. The results are tabulated in Table 7.

---

*Data supplied by NWL/D.

Table 7. SUMMARY OF SCC FAILURE RATES

Assembly	Operating Hours	Failures	$\lambda (x\ 10^{-6})$	MTBF (Hours)
A01	1823	1	548.55	1823
A04	1823	1	548.55	1823
A06	1823	1	548.55	1823
A07	1972	9	4563.89	219
SCC			6209.54	161

A stress-analysis prediction of the reliability of the SCC was performed. Parts count was attained by using a combination of NAVORD OP 4219 (Interim Issue), and Honeywell Incorporated's Reliability and Maintainability Prediction Report for CPIC RGFCS SCC, dated 15 November 1973. These two sources present some discrepancy in parts count since the OP reflects the prototype version of the SCC and the prediction report was stated by Honeywell to represent their best estimate of the production-model configuration.* Discrepancies are noted on the prediction worksheets, Appendix C.

MIL-HDBK-217A was used as the primary source for piece-part failure data. When data were unavailable from this source, the manufacturer's data were used. All base failure rates and stress and environmental factors used are tabulated in Appendix C.

Since a piece-part breakdown was unavailable for Assembly A07 (Computer), Cable Harness, Door, or RF Plumbing, the manufacturer's failure rate data were used.

Results of the reliability stress-analysis prediction are tabulated in Appendix C and summarized in Table 8.

Table 9 summarizes the probability of completing missions of varying durations based on MTBFs determined from prediction and trial data.

The reliability prediction summarized in Table 8 indicates that the greatest potential for SCC failure is in the upper and lower converter assemblies (A06 and A08), with an MTBF of 366 hours; and then in the target and director assembly (A01), with an MTBF of 425 hours.

Assemblies A06 and A08 contain 48 logic, converter, or multiplexing cards of varying complexity. A failure in either of these assemblies could prevent properly training or elevating the gun mount and cause improper operation of the remote optical sight in slaving to the target or coasting.

*From 21 May 1974 meeting at Honeywell, Inc., West Covina, California.

Assembly	Failures Per Million Hours		
	Honeywell Prediction	ARINC Research Prediction	
		T_a = 30°C	T_a = 65°C
A01 - Target and Director	330.95	2350.53	2463.22
A02 - Plan Position*	-	-	-
A03 - True North	13.53	13.53**	13.53**
A04 - Mount and Status	63.166	215.03	279.39
A05 - System Status	48.42	60.34	60.34
A06 - Upper Converter	413.37	2732.09	3658.82
A07 - Computer H316R	540.18	540.18**	540.18**
A08 - Lower Converter	413.37	2732.09	3658.82
A09 - Switchboard and Power Supply	124.17	192.36	225.06
A10 - Right Rear Connector	2.74	2.74	2.74
A11 - Left Rear Connector	0.08	0.09	0.09
Door	4.58	4.58**	4.58**
Cable	1.29	1.29**	1.29**
RF Plumbing	28.389	28.39**	28.39**
Total System	1984.235	8873.24	10936.45

Table 8. RELIABILITY PREDICTION SUMMARY

*No parts count available; part of LN66HP Radar.
**No parts count available; use Honeywell predicted data.

Table 9. SCC RELIABILITY FOR SEVERAL MTBFs AND MISSION LENGTHS

Mission Length (t hours)	Reliability, R(t)		
	Trial Data MTBF = 161 hours	Prediction	
		MTBF = 113 hours (T_a = 30°C)	MTBF = 91 hours (T_a = 65°C)
15	0.9110	0.8757	0.8487
30	0.83	0.7668	0.7203
45	0.7562	0.6715	0.6113
60	0.69	0.588	0.5188

Assembly A01 contains 17 TWS, I/O buffer, and multiplexing cards of varying complexity. If this assembly fails, it is possible that no information, or incorrect information, will be processed through the RGFCS, affecting gun and director orders, FCS tracking capability, and data display.

The observed MTBF for assemblies A01 and A06, based on trial data, is 1823 hours. No failure was recorded for assembly A08 in 1823 hours of operation.

On the basis of the trial data, assembly A07, the H316R computer, appears to offer the greatest potential for failure. It demonstrated an MTBF of 219 hours (9 failures in 1972 hours of operation). The MTBF predicted by Honeywell is 1851 hours, which makes the H316R first in criticality in the Honeywell prediction but third in ARINC Research's prediction. Since the computer is the heart of the RGFCS, its reliability is critical to the reliability of the system.

3.3.3.2 SCC Maintainability

A consideration that has not been treated in this report but should eventually be treated is the physical location of the SCC aboard the craft. An investigation should be conducted to determine whether the SCC can be located so that there is ready access to all assemblies for testing and component replacement.

The system maintenance concept has not yet been established in final form. Before it is, consideration must be given to the system integrated test capability, qualifications of operating crew members, on-board storage capacity, and those components which constitute potentially high-failure items. A brief discussion of these items follows.

Integrated Test Capability

The SCC is designed so that its operability and readiness can be checked through a daily system operational test (DSOT), false target and TWS test, and system interface test.

The DSOT uses the computer to verify proper operation of the following:

- The pit log interface board, A01A10
- Display indicators
- Synchro/Digital, Digital/Synchro, Analog/Digital, Digital/Analog converters in assemblies A06 and A08
- Assembly A03, true north module, antenna switch, and video signals

False Target and TWS Test

By generating and moving a false target, it is possible to check proper operation of certain I/O and TWS logic boards in Assembly A01, as well as a portion of the radar computer interfaces.

System Interface Test

The System Interface Test verifies proper operation of the status indicators (TWS1, TWS2, Cursor, Mount SYNC, and TRUE-REL) on the director panels and the SCC.

Operating Maintenance Personnel

Personnel assigned to the SCC operating station aboard CPIC must be thoroughly familiar not only with system operation but also with all of the system components. It does not appear economically feasible for the craft to have the luxury of separate operating and maintenance personnel to carry out a 60-hour mission.

As described above, the computer is an integral part of the DSOT. Consequently, SCC personnel assigned must be capable of interpreting the computer output when running DSOT as well as determining trouble in the I/O and TWS logic boards during a false-target test. They should be capable of isolating and replacing a faulty logic board (if one is carried as "on board" spare) while under way to minimize the probability of aborting the mission and returning to port.

On-Board Storage

The type and quantity of spare parts carried aboard CPIC during at-sea operations will be dependent, in part, on the storage space available. Since ARINC Research has no knowledge of space allocations aboard the craft, the subject cannot be addressed at this time.

Potential High-Failure Items

On the component level, the only component with a failure rate equal to or greater than 50 failures per million hours of operation is power supply PS1 in Assembly A09. The source of this component's failure rate (54 failures per million hours of operation) is the Almond Instruments Corporation; it is based on a prediction for an equivalent power supply.

Assemblies and subassemblies that are predicted to fail at a rate equal to or greater than 50 times per million hours of operation are listed in Appendix D.

Those items of the SCC whose failures could cause failure of the RGFCS in all modes of operation are shown in Figure 8. Since the H316R computer (Assembly A07) is critical to the RGFCS operational and integrated test capability and has a demonstrated low MTBF, it is recommended that consideration be given to replacing it with a more reliable computer in the production CPIC RGFCS.

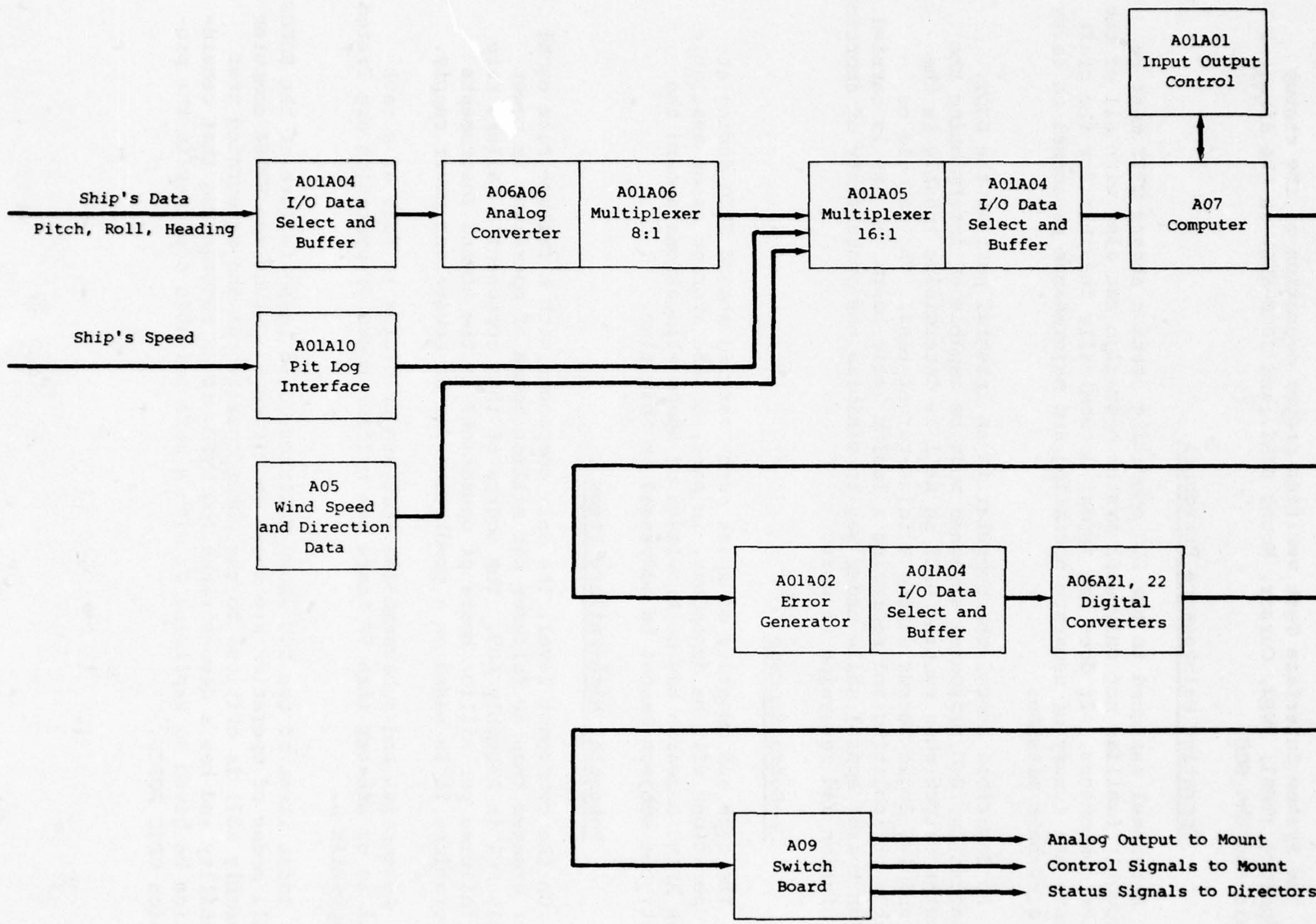


Figure 8. CRITICAL ASSEMBLIES/SUBASSEMBLIES IN SCC

3.4 FREQUENCY CONVERTERS

3.4.1 Subsystem Description

The Coastal Patrol and Inderdiction Craft employs two VARO frequency converters: a 5-kVA, 400-Hz, 1-phase Model 100-153; and a 1-kVA, 400-Hz, 3-phase Model 100-152. The 1-phase converter supplies power for the SCC, Mk 74 Mod 0, and Mk 35 Mod 0. The 3-phase converter supplies power for the Mk 5 Mod 0 Gyro Stabilizer. Figure 9 shows the CPIC 400-Hz power distribution.

3.4.2 Discussion

The prototype craft has experienced no failures in the 3-phase converter.

The 1-phase 5-kVA converter has experienced seven documented and several undocumented failures during at-sea tests. Five of the seven documented failures were blown fuses, which occurred when ship service power was shifted from shore to ship or the 440-Vac, 3-phase, 60-Hz power was secured without first securing the converter. The problems associated with the 1-phase 5-kVA converter are under study by the manufacturer, and the converter has been modified. Detailed design data are not currently available on this modified converter.

Consideration should be given to the following aspects of frequency-converter use in the production model of the CPIC:

- Cooling and ventilation of the units will be an absolute requirement; thus their location is extremely important. Dependence upon an air-conditioned space for cooling is unadvisable, since the weapon system should be independent of the ship service habitability subsystems.
- The Coastal Patrol and Interdiction Craft System Functional Diagrams (SFD), Change 1 of March 1973, indicate that the thermal protective switches are not used in either converter. Thermal protection for the converters will be essential in the production CPIC and should be provided, along with a remote bypass and warning indicator.
- The problems encountered to date with the craft's 400-Hz power supplies indicate that it would be advisable to review the total 400-Hz power requirements and distribution system. The possibility of using a single 3-phase, 400-Hz converter or motor generator to supply all 400-Hz power should be investigated. Since space and weight in the CPIC will always be of concern, this should be a consideration when the 400-Hz power system is being reviewed.

3.4.3 Reliability and Maintainability Analysis

During the OSSIT period, a variety of 1-phase 400-Hz sources were employed. The Model 100-153 was installed in the CPIC after it had

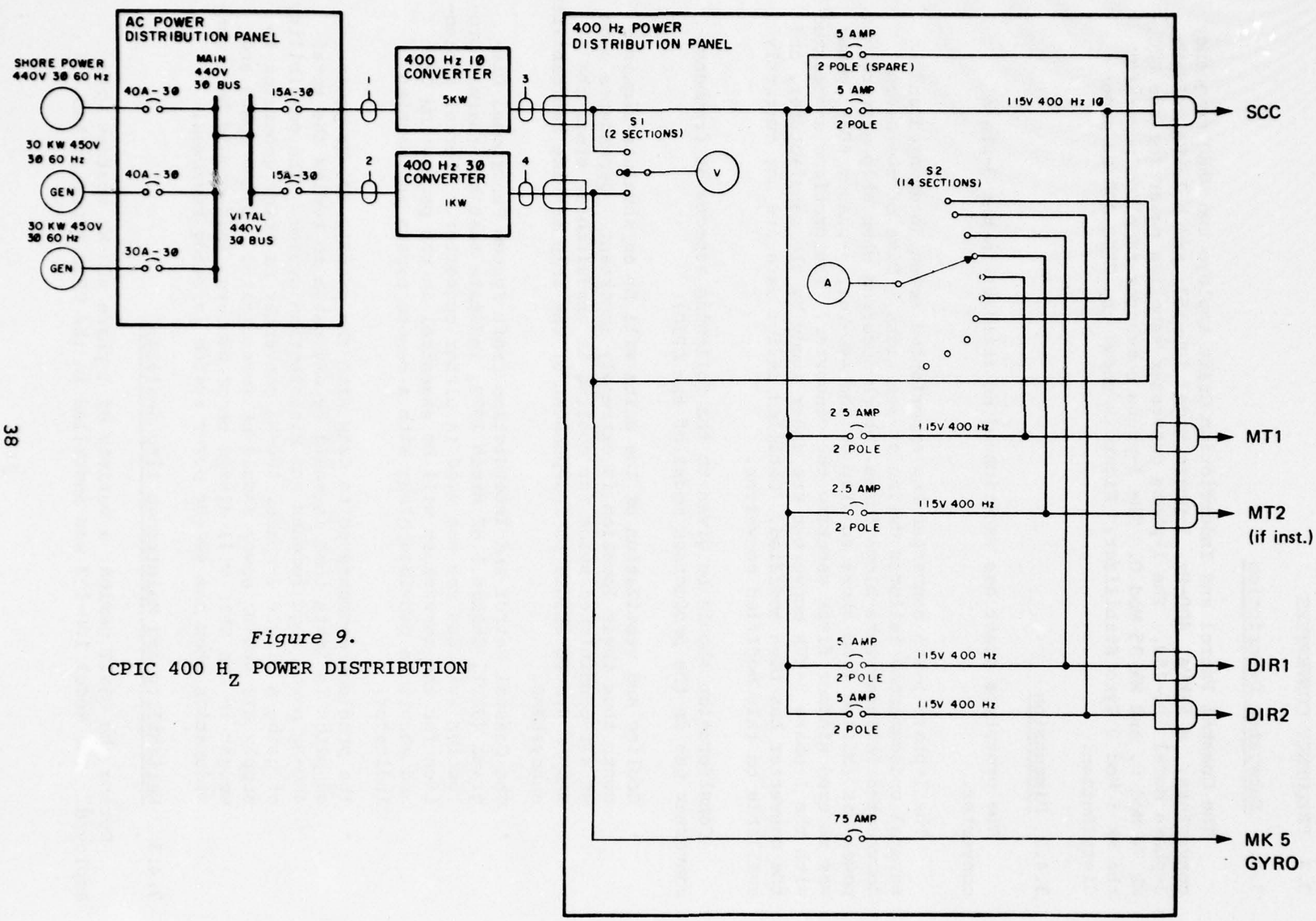


Figure 9.

CPIC 400 H_Z POWER DISTRIBUTION

accumulated a total of 672 operating hours divided between the manufacturer and the OSSIT. There are no records of failures during this first 672-hour period. During the at-sea period the Model 100-153 operated a total of 589 hours, during which the seven recorded failures discussed above occurred. Since it appears that the failures can be directly attributed to the CPIC installation and operating conditions, a point estimate of MTBF for the CPIC installation can be calculated to be 84 hours, with a 60-hour mission reliability of 0.4901. It must be emphasized that these figures are based on incomplete failure data and the fact that the converter was modified during this period. A new analysis and prediction will be required when the firm configuration of the 1-phase converter is established. Appendix B contains details of the failures discussed above.

Failure of the 3-phase converter would result in loss of the Mk 5 gyro, with accompanying loss of gun mount stabilization. The weapon system would still be operable, but capability would be reduced, especially in moderate to heavy seas.

Failure of the 1-phase converter would result in serious degradation of the weapon suite, and the mounts would have to be operated locally.

The converters should present no serious maintenance problems for the ROKN personnel, since they are less complex than the SCC or the radar.

Both converters are straightforward solid-state units that should require a minimum of preventive maintenance beyond cleaning filters and periodic output check.

3.5 MK 5 MOD 0 GYRO-STABILIZER

3.5.1 Subsystem Description

The Mk 5 Mod 0 Gyro-Stabilizer consists of a gyro unit and a controller unit. The gyro-stabilizer furnishes pitch and roll data to the Mk 93 Mod 0 Radar Gun Fire Control System (RGFCS) for stabilization of the gun mounts. The gyro-stabilizer requires inputs from the Mk 27 Mod 1 Gyro-Compass in addition to 115V, 400-Hz, 3-phase power and 110V, 60-Hz, 1-phase power.

3.5.2 Discussion

The Mk 5 Mod 0 is a standard gyro-stabilizer system that has been in use for a number of years for stabilization of shipborne equipment, such as degaussing systems. The Mk 5 was analysed for interface problems only.

3.5.3 Reliability and Maintainability

As directed by NOSL, no analysis of the Mk 5 reliability and maintainability was performed. No previous use of the Mk 5 to stabilize a weapon system could be ascertained. The available CPIC data do not give any

indication of failures, nor do they indicate system performance. There are no apparent interface problems with the Mk 5 as currently installed.

Failure of the Mk 5 would result in loss of mount stabilization. The weapon system would still be operable, but capability would be reduced, especially in moderate to heavy seas.

CHAPTER FOUR

SURVIVABILITY AND RELIABILITY

4.1 SURVIVABILITY

Survivability is "the measure of the degree to which an item will withstand hostile man-made environment and not suffer abortive impairment of its ability to accomplish its designated mission".* The survivability of the CPIC Weapon System, then, will be a measure of its ability to withstand battle damage and continue to engage surface and air threats.

The CPIC is not armored, and the weapon system is vulnerable primarily to topside battle damage. Its physical location isolates it from all damaging effects of underwater explosives except shock.

The CPIC's defense lies in its high speed and maneuverability, along with its *limited radar cross section and nondeterminative radar signature.*

The CPIC Weapon System, with the exception of the magazine, is located in the central one-third of the craft above the main deck. The 30mm magazine is approximately 30 feet aft of the bow below the main deck but above the design water line.

To a great extent, weapon system survivability is a subjective assessment. The approach used was to identify and group the various major components of the weapon system according to their physical location. The next step was to identify three possible situations under which the CPIC might be required to operate *after* encountering hostile-action damage:

- Surface engagement with a hostile combatant attempting infiltration
- Self defense from air attack while conducting anti-infiltration patrol (The air threat may be either missile or manned aircraft, and these will be engaged with the weapon system in local-powered mode.)
- Navigating and evading detection while transiting from an engagement that resulted in weapon system damage

---

*MIL-STD-721B.

Each of these three situations was further addressed from the point of view of day or night encounter. Finally, a coding system was developed to indicate the weapon system level of degradation that would result from the loss of a major component to enemy action. In each case it was assumed that the damage to a major component would totally disable that particular component. The coding system is as follows:

A - Would have no effect on the situation, as the component is not required.

B - Would have minimal effect on the situation because of the availability of an alternate mode of operation. Mode-selection options would be limited.

C - CPIC performance would be seriously degraded (estimated that less than 50-percent weapon system capability would remain).

D - Assigned-mission continuation would not be advisable, and the mission would have to be aborted (break engagement; discontinue patrol and request assistance; depart area if possible).

In all cases it was assumed that the battle damage was limited to the weapon system and that the craft mobility and ship service power were unimpaired.

Survivability assessments could be carried to lower levels and could be further developed to include mixes of systems involved, but it would be of questionable value at this time to carry the study to such lengths.

The survivability assessment should be viewed as one of the items to be considered in the development of the production CPIC.

The installation of redundant subsystems or the inclusion of additional emergency modes of operation may increase the CPIC's ability to withstand damage to the weapon system and continue its assigned mission, but the nature of the craft precludes heavy armor and multiple weapon systems. The CPIC has minimal casualty-control capability; thus it must be assumed that in most cases damage to the weapon system would result in discontinuing the engagement and leaving the operating area.

Assessment of the survivability of the weapon system with respect to self-inflicted damage will require measurement of CPIC operational-environmental characteristics (shock, vibration, etc.), which are not available at this time. The end result will not change; the loss of a subsystem, regardless of the cause, will result in the same mission degradation.

Figure 10 is a CPIC survivability matrix showing the result of the loss of any one subsystem in the three possible situations. The loss of more than one subsystem is not addressed, but the result can be surmised by using this matrix. It can be seen that the redundancy of subsystems and the multiple modes of operation permit the CPIC to continue its interdiction mission as long as the mount is functioning. Since in the prototype system the gun mount has no redundancy, it is the major critical item in the weapon system.

Subsystem	Situation					
	Surface Engagement		Air Defense*		Navigate, Evade, Transit	
	Day	Night	Day	Night	Day	Night
Gun Mount	D	D	D	D	A	A
Magazine	C	C	D	D	A	A
Mast-LN66 Ant.	B	C	B	B	B	C
LN66 R/T	B	C	B	B	B	C
No. 1 Periscope	B	B	B	B	B	B
No. 2 Periscope	B	B	B	B	B	B
Mk 35 J/B	C	C	B	B	B	B
SCC/H316R	C	C	A	A	B	C
1 Phase Conv.	C	C	D	D	C	C
3 Phase Conv.	B	B	B	B	A	A
Mk 5 Gyro	B	B	B	B	A	A

*Local-powered mode would be used for Air Defense.

Code

A - Would have no effect on the situation, as the component is not required.

B - Would have minimal effect on the situation because of the availability of an alternate mode of operation. Mode-selection options would be limited.

C - CPIC performance would be seriously degraded (estimated that less than 50-percent weapon system capability would remain).

D - Assigned-mission continuation would not be advisable, and the mission would have to be aborted (break engagement; discontinue patrol and request assistance; depart area if possible).

Figure 10. CPIC SURVIVABILITY MATRIX

In all of the foregoing, it has been assumed that the assigned mission is patrol and interdiction and that the surface threat is one with a less capable weapon system than the CPIC. If the CPIC is faced with a threat with equal or greater weapon system capability, the decision to break the engagement, if possible, may be different from that in Figure 10.

4.2 RELIABILITY

Reliability is "the probability that an item will perform its intended function for a specified interval under stated conditions".*

The first assessment of total weapon system reliability was developed from failure rates derived by measuring the performance of each major subsystem, both during On-Shore System Integration Test (OSSIT) and at sea. Because each major subsystem is fairly complex and comprises many component parts, each subsystem was assumed to have an exponential failure distribution (a constant failure rate). The failure rate for each subsystem, based on test results, is developed in Appendix B of this report, which also shows the derived MTBF for each subsystem.

Figure 11 presents the CPIC Weapons System Reliability Block Diagram depicting the various mission modes. The system configuration evaluated one LN66HP Radar, one System Control Console (SCC), one Mk 74 30mm Gun Mount, one Mk 5 Gyro Stabilization Unit, one three-phase Frequency Converter, one single-phase Frequency Converter, two Mk 35 Optical Directors, and two HS 831 A/L 30mm Guns. The Split Mode is the most complex and utilizes all of the component blocks. Therefore, this mode is depicted in Figure 11 by the solid black arrows. Other modes of operation are illustrated by dots, dashes, or dots and dashes, as shown in the legend. (Block 1 is the input terminal for all modes except for "Local Powered", which begins with its input to Block 3.)

Table 10 presents mission reliabilities for various system modes and for two different mission durations (15 and 60 hours). The reliability calculations are based on test data presented in Appendix B, except for the single-phase frequency converter, which experienced seven failures. The manufacturer is reported to have redesigned portions of the converter, which should substantially reduce the failure rate. Therefore, for these calculations only a single failure of that unit was assumed ($\lambda = 1698 \times 10^{-6}$).

Gun reliability was calculated for three separate modes of operation. The probability that the guns will complete an uninterrupted 20-round burst was calculated to be 0.965461. The probability that either or both guns could complete a 20-round burst, not counting clearable stoppages, is 0.999498. The probability that the two guns will complete a 500-round mission, not counting clearable stoppages, is calculated to be 0.81523640, from the equation derived in Appendix A.

---

*MIL-STD-721B.

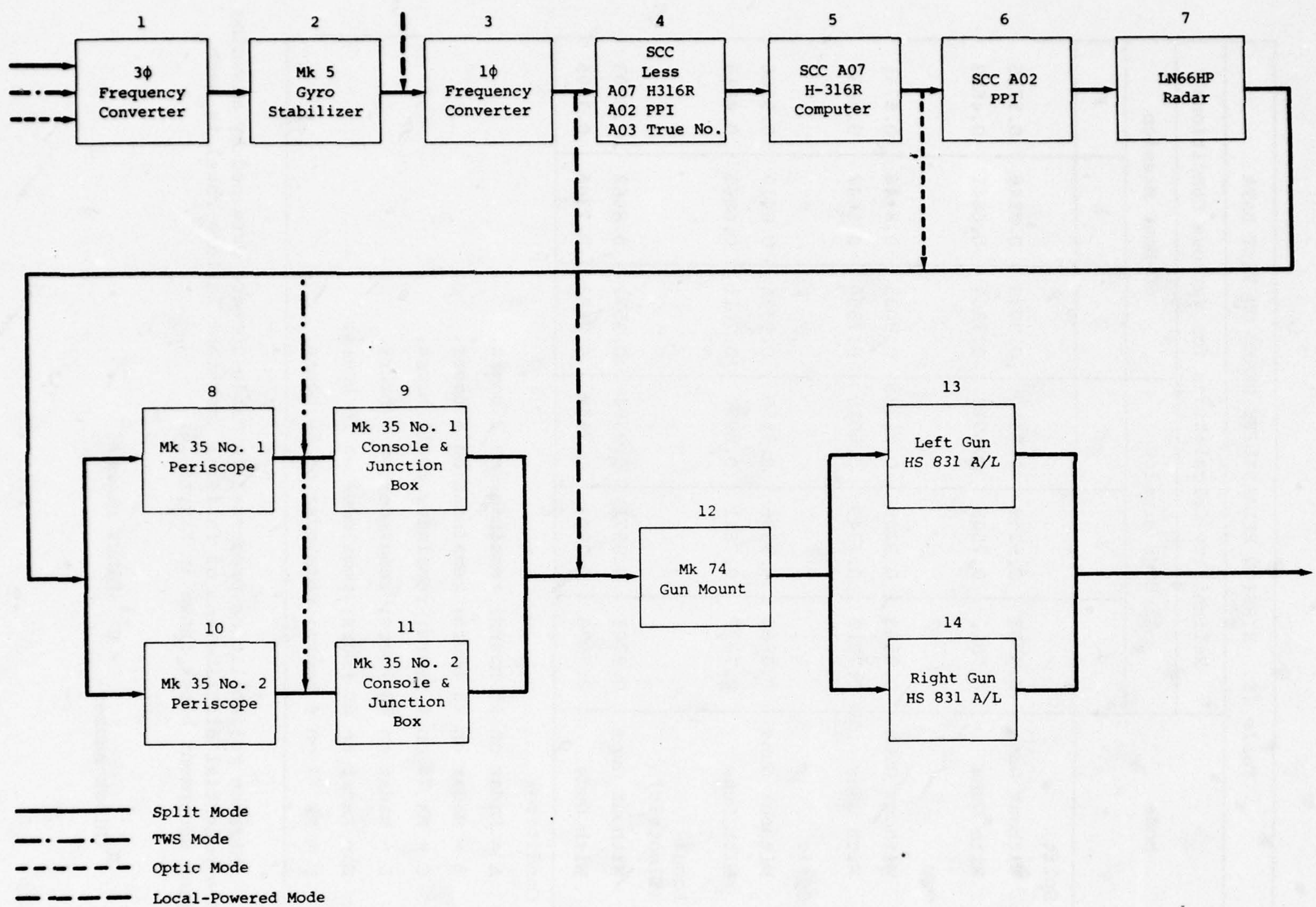


Figure 11. **WEAPON SYSTEM RELIABILITY BLOCK DIAGRAM**

Table 10. MISSION RELIABILITY BASED ON TEST DATA						
Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Split						
Without Guns	0.9583	0.9259	0.8480	0.9033	0.8146	0.5715
With Guns	0.7812	0.7548	0.6913	0.7364	0.6641	0.4659
TWS						
Without Guns	0.9583	0.9259	0.8483	0.9033	0.8148	0.5751
With Guns	0.7813	0.7549	0.6919	0.7364	0.6642	0.4688
Optic						
Without Guns	0.9662	0.9336	0.8550	0.9336	0.8419	0.5906
With Guns	0.7877	0.7611	0.6970	0.7611	0.6863	0.4815
Local (Electric)						
Without Guns	0.9783	0.9571	0.9394	0.9571	0.8962	0.8703
With Guns	0.7976	0.7803	0.7658	0.7803	0.7306	0.7095

Condition:

A = Radar on 16 hours; remainder on 2 hours.

B = Radar on 15 hours; remainder on 4 hours.

C = Mk 74 on 4 hours; remainder on 15 hours.

D = Radar on 60 hours; remainder on 4 hours.

E = Radar on 60 hours; remainder on 10 hours.

F = Mk 74 on 4 hours; remainder on 60 hours.

Mission reliabilities presented in Table 10 were obtained by assuming an exponential distribution of failures (constant failure rate) in each major equipment block shown in Figure 11:

$$R_{(\text{Block number})} = e^{-\lambda_{(\text{Block number})} t}$$

where

$$\lambda_{\text{(Block number)}} = \frac{1}{\text{MTBF}}$$

t = mission time for that block

The $\lambda_{\text{(Block number)}}$ for each equipment block except Blocks 3, 13, and 14 is developed in Appendix B. Block 3, the single-phase converter, was assumed to have one failure in 589 hours of operation. The reliability for the guns (Blocks 13 and 14 combined) was assumed to be 0.8152364 (for 500 rounds). Table 10 presents mission reliabilities, with and without the guns included. The reliability equations for the four modes are as follows:

$$R_{Split} = R_1 \cdot R_2 \cdot R_3 \cdot R_4 \cdot R_5 \cdot R_6 \cdot R_7 \cdot [(R_8 \cdot R_9) + (R_{10} \cdot R_{11}) - (R_8 \cdot R_9 \cdot R_{10} \cdot R_{11})] \cdot R_{12} \cdot (R_{13,\ 14})$$

$$R_{TWS} = R_1 \cdot R_2 \cdot R_3 \cdot R_4 \cdot R_5 \cdot R_6 \cdot R_7 \cdot [R_9 + R_{11} - (R_9 \cdot R_{11})] \cdot R_{12} \cdot (R_{13,\ 14})$$

$$R_{Optic} = R_1 \cdot R_2 \cdot R_3 \cdot R_4 \cdot R_5 \cdot [(R_8 \cdot R_9) + (R_{10} \cdot R_{11}) - (R_8 \cdot R_9 \cdot R_{10} \cdot R_{11})] \cdot R_{12} \cdot (R_{13,\ 14})$$

$$R_{Local} = R_3 \cdot R_{12} \cdot (R_{13,\ 14})$$

Many managers are often more familiar with Mean Time Between Failures (MTBF) values as a means of evaluating system performance. Mission reliability for a system that has an exponential failure rate is

$$R = e^{-\frac{t}{\text{MTBF}}}$$

System MTBFs based on the test results are presented in Table 11. This table is based on a system that would have only one director, since redundancy cannot be easily accounted for by this method. The redundant optical director should make system performance even better than that reflected in the reported MTBFs. The guns are never accounted for in these MTBF calculations, since their dominant failure mode involves rounds fired and is expressed as Mean Rounds Between Failures (MRBF).

Table 11. SYSTEM MTBFS		
	MTBF in Hours	
System Configuration	OSSIT and At-Sea Tests Combined	At-Sea Tests Only
LN66HP Radar, SCC, and one Mk 35 Optical Director	112	140
Same as above plus 1ϕ Frequency Converter, 3ϕ Frequency Converter, and Mk 5 Gyro	94	113
Same as above plus the Mk 74 Gun Mount	50	113

The only subsystem for which sufficient data were available to perform a prediction was the System Control Console (SCC). The prediction results for this major unit are presented in Table 8 in Section 3.3.3.1 for temperatures of +30°C and +65°C, as required under terms of the contract. The mission reliability was calculated by using the test data for all assemblies except the SCC; the +30°C predicted failure rate was used for the SCC. These results are presented in Table 12. Each mode and condition is slightly less successful than that shown in Table 10, in which only test results are used (except for the last, Local-Powered Mode, which is unchanged because the SCC is not used in this mode).

Table 13 is based on these same data, except that the predicted failure rates for the SCC are based on +65°C. As would be expected, the mission reliabilities involving the SCC are slightly less successful at the elevated temperatures.

From the data in Appendix B it can be seen that the SCC was a major failure source during the tests. However, of a total of 12 experienced failures, nine occurred in the A07 Computer (H316R). Of the remaining three failures, only one, a synchro-to-digital converter, occurred at sea. Therefore, the performance of the SCC, excluding the A07 Computer, is good.

The computer has not proven itself reliable during these tests. The manufacturer states that the test failure rate is substantially higher than that experienced on the commercial H316 computers. There are no firm reliability data on commercial units to substantiate that claim. However, the claim seems reasonable, since continued failures at this rate would have been disastrous for a commercial program. There is a possibility that the A07 used in the test was a singularly bad computer, a "lemon". Changing computers at this time would involve great technical risk; not changing the computer represents a significant reliability risk. No recommendation can be made on the basis of the available data.

Table 12. MISSION RELIABILITY BASED ON TEST DATA AND SCC PREDICTION AT +30°C						
Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Split						
Without Guns	0.9533	0.9163	0.8153	0.8939	0.7935	0.4883
With Guns	0.7772	0.7470	0.6646	0.7287	0.6469	0.3981
TWS						
Without Guns	0.9533	0.9163	0.8156	0.8939	0.7938	0.4914
With Guns	0.7772	0.7470	0.6649	0.7288	0.6470	0.4006
Optic						
Without Guns	0.9612	0.9238	0.8220	0.9238	0.8201	0.5047
With Guns	0.7836	0.7531	0.6701	0.7531	0.6686	0.4114
Local (Electric)						
Without Guns	0.9783	0.9571	0.9394	0.9571	0.8962	0.8703
With Guns	0.7976	0.7803	0.7658	0.7803	0.7306	0.7095

Condition:

A = Radar on 16 hours; remainder on 2 hours.

B = Radar on 15 hours; remainder on 4 hours.

C = Mk 74 on 4 hours; remainder on 15 hours.

D = Radar on 60 hours; remainder on 4 hours.

E = Radar on 60 hours; remainder on 10 hours.

F = Mk 74 on 4 hours; remainder on 60 hours.

Table 13. MISSION RELIABILITY BASED ON TEST DATA AND SCC PREDICTION AT +65°C

Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Split						
Without Guns	0.9494	0.9087	0.7904	0.8865	0.7773	0.4315
With Guns	0.7740	0.7408	0.6444	0.7227	0.6337	0.3517
TWS						
Without Guns	0.9494	0.9083	0.7908	0.8866	0.7775	0.4342
With Guns	0.7740	0.7409	0.6447	0.7228	0.6338	0.3540
Optic						
Without Guns	0.9572	0.9162	0.7970	0.9162	0.8033	0.4459
With Guns	0.7804	0.7470	0.6497	0.7470	0.6549	0.3635
Local (Electric)						
Without Guns	0.9783	0.9571	0.9394	0.9571	0.8962	0.8703
With Guns	0.7976	0.7803	0.7658	0.7803	0.7306	0.7095

Condition:

A = Radar on 15 hours; remainder on 2 hours.
B = Radar on 15 hours; remainder on 4 hours.
C = Mk 74 on 4 hours; remainder on 15 hours.
D = Radar on 60 hours; remainder on 4 hours.
E = Radar on 60 hours; remainder on 10 hours.
F = Mk 74 on 4 hours; remainder on 60 hours.

The tests show that the most frequently failing unit was the single-phase frequency converter. The performance of the test unit was not acceptable. However, the manufacturer has identified problem areas and redesigned portions of the unit. There are no representative data on the redesigned unit.

The Mk 74 gun mount was the second least reliable unit during the tests. Portions of the mount were redesigned by the manufacturer. It is expected that the redesigned unit will reduce the number of failures experienced. However, no data on the redesigned areas have been received by ARINC Research for analysis. One area of improvement potential is the battery, the primary power source for mount operation. Failure of the battery would prevent the mount from functioning. It is recommended that ship power be made the primary source of mount power and that the battery be retained as an alternate power source.

The next most frequently failing unit was the Optical Director No. 2 Console Assembly. However, this assembly has the same design as the No. 1 Console, which had a low failure rate. Averaging the two like units' failure rates results in reasonable performance. Further, the operational redundancy of the two optical directors yields a performance expectation that would not warrant any major expenditures of funds for improvements at this time.

Increased mission reliability could be obtained for the weapon system if an operational mode were incorporated that would allow direct control of the mount from either optical director. (A failure of the SCC would not prevent operation of the mount from the bridge.) Such a mode would require modifying the system to utilize the Mk 5 to stabilize the mount while bypassing the SCC, or the present optic system could be operated in the GYRO BYPASS mode, with the result that the system would be unstabilized. This mode would lack the computer-generated gun orders available in the present optic mode but would offer the advantage over the manually powered mode of making two directors available in the pilot house, with their improved optics and better command and control by the OIC. Range data would be estimated as in the present manually powered mode. The proposed mode would use all of the blocks in Figure 11 except the SCC and the Radar. The expected mission reliability in this mode, based on the same test data used for developing Table 10, is presented in Table 14. The reliability equation for this mode is

$$R_{\substack{\text{Proposed}\\ \text{Optic}}} = R_1 \cdot R_2 \cdot R_3 \cdot [(R_8 \cdot R_9) + (R_{10} \cdot R_{11}) - (R_8 \cdot R_9 \cdot R_{10} \cdot R_{11})] \cdot R_{12} \cdot (R_{13,\ 14})$$

Table 14. PROPOSED OPTIC MODE MISSION RELIABILITY BASED ON TEST DATA						
Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Proposed Optic Mode						
Without Guns	0.9783	0.9570	0.9384	0.9570	0.8958	0.8573
With Guns	0.7976	0.7802	0.7651	0.7802	0.7303	0.6989

Condition:

A = Radar on 15 hours; remainder on 2 hours.

B = Radar on 15 hours; remainder on 4 hours.

C = Mk 74 on 4 hours; remainder on 15 hours.

D = Radar on 60 hours; remainder on 4 hours.

E = Radar on 60 hours; remainder on 10 hours.

F = Mk 74 on 4 hours; remainder on 60 hours.

It is recognized that for such a mode, additional circuitry would be required to allow one director or the other to take control of the mount. However, it is apparent from Table 14 that the reliability attainable in this mode would approach that realized when the mount is used in the Local-Powered mode, and mount control from the bridge would be retained. A cost-effectiveness study of this mode is recommended.

Consideration was given to possible configurations of the equipment other than those which existed at OSSIT and in the prototype CPIC. Specifically, a system with only one optical director and one gun mount and a system with two optical directors and two gun mounts were considered.

Table 15 shows the system reliabilities based on test data exactly as presented in Table 11, except that only one optical director is considered, as shown in Figure 12. The mission reliabilities are slightly reduced, as would be expected, since the redundancy of the second optical director no longer exists.

Table 16 shows the system reliabilities based on test data exactly as presented in Table 11, except that a second Mk 74 Gun Mount with dual guns has been added, as shown in Figure 13. Both the gun mount and the guns are relatively low-reliability items, and this redundancy brings the

mission reliability to a fairly high value, as expected. However, in practice such redundancy would entail adding a relatively high-cost unit, with considerable weight, to the craft. Therefore, the weapon system's increased mission reliability would not be attained without penalty to other areas of the program.

Table 15. MISSION RELIABILITY BASED ON TEST DATA CONFIGURATION: ONE OPTICAL DIRECTOR, ONE GUN MOUNT

Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Split						
Without Guns	0.9542	0.9180	0.8216	0.8956	0.7974	0.5091
With Guns	0.7779	0.7484	0.6698	0.7301	0.6501	0.4151
TWS						
Without Guns	0.9552	0.9200	0.8283	0.8975	0.8018	0.5260
With Guns	0.7787	0.7500	0.6753	0.7317	0.6536	0.4288
Optic						
Without Guns	0.9621	0.9255	0.8284	0.9255	0.8241	0.5262
With Guns	0.7843	0.7545	0.6753	0.7545	0.6719	0.4290
Local (Electric)						
Without Guns	0.9783	0.9571	0.9394	0.9571	0.8962	0.8703
With Guns	0.7976	0.7803	0.7658	0.7803	0.7306	0.7095

Condition:

A = Radar on 15 hours; remainder on 2 hours.

B = Radar on 15 hours; remainder on 4 hours.

C = Mk 74 on 4 hours; remainder on 15 hours.

D = Radar on 60 hours; remainder on 4 hours.

E = Radar on 60 hours; remainder on 10 hours.

F = Mk 74 on 4 hours; remainder on 60 hours.

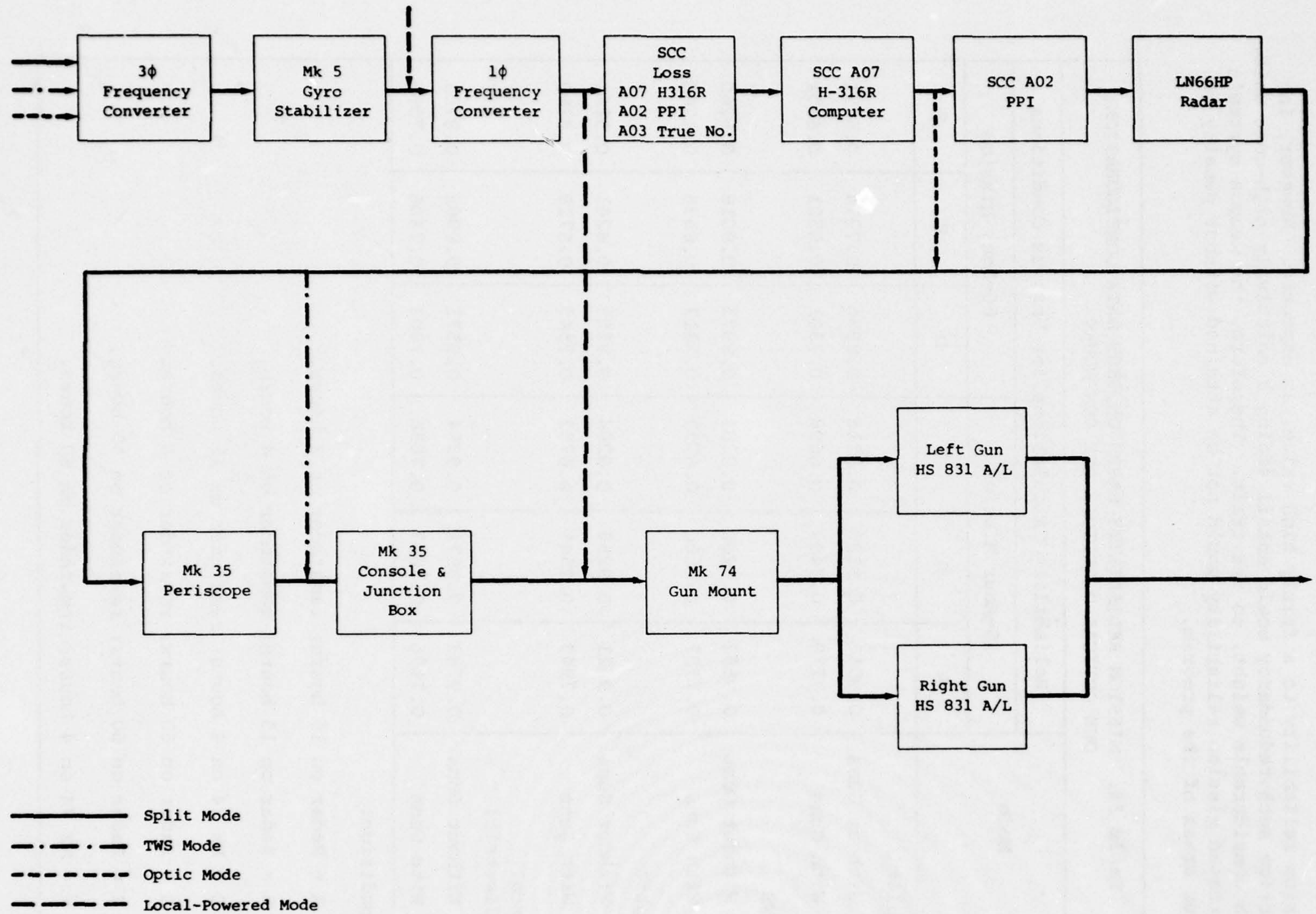


Figure 12. RELIABILITY BLOCK DIAGRAM FOR ONE DIRECTOR

Table 16. MISSION RELIABILITY BASED ON TEST DATA CONFIGURATION: TWO OPTICAL DIRECTORS, TWO GUN MOUNTS

Mode	Reliability Calculations for Various Conditions					
	15-Hour Mission			60-Hour Mission		
	A	B	C	D	E	F
Split						
Without Guns	0.9759	0.9596	0.8788	0.9362	0.8866	0.5922
With Guns	0.9373	0.9167	0.8395	0.8943	0.8347	0.5658
TWS						
Without Guns	0.9759	0.9596	0.8792	0.9362	0.8868	0.5960
With Guns	0.9373	0.9167	0.8399	0.8943	0.8348	0.5694
Optic						
Without Guns	0.9840	0.9675	0.8861	0.9675	0.9163	0.6121
With Guns	0.9450	0.9243	0.8464	0.9243	0.8626	0.5847
Local (Electric)						
Without Guns	0.9963	0.9919	0.9736	0.9919	0.9755	0.9019
With Guns	0.9569	0.9476	0.9300	0.9476	0.9183	0.8616

Condition:

A = Radar on 15 hours; remainder on 2 hours.

B = Radar on 15 hours; remainder on 4 hours.

C = Mk 74 on 4 hours; remainder on 15 hours.

D = Radar on 60 hours; remainder on 4 hours.

E = Radar on 60 hours; remainder on 10 hours.

F = Mk 74 on 4 hours; remainder on 60 hours.

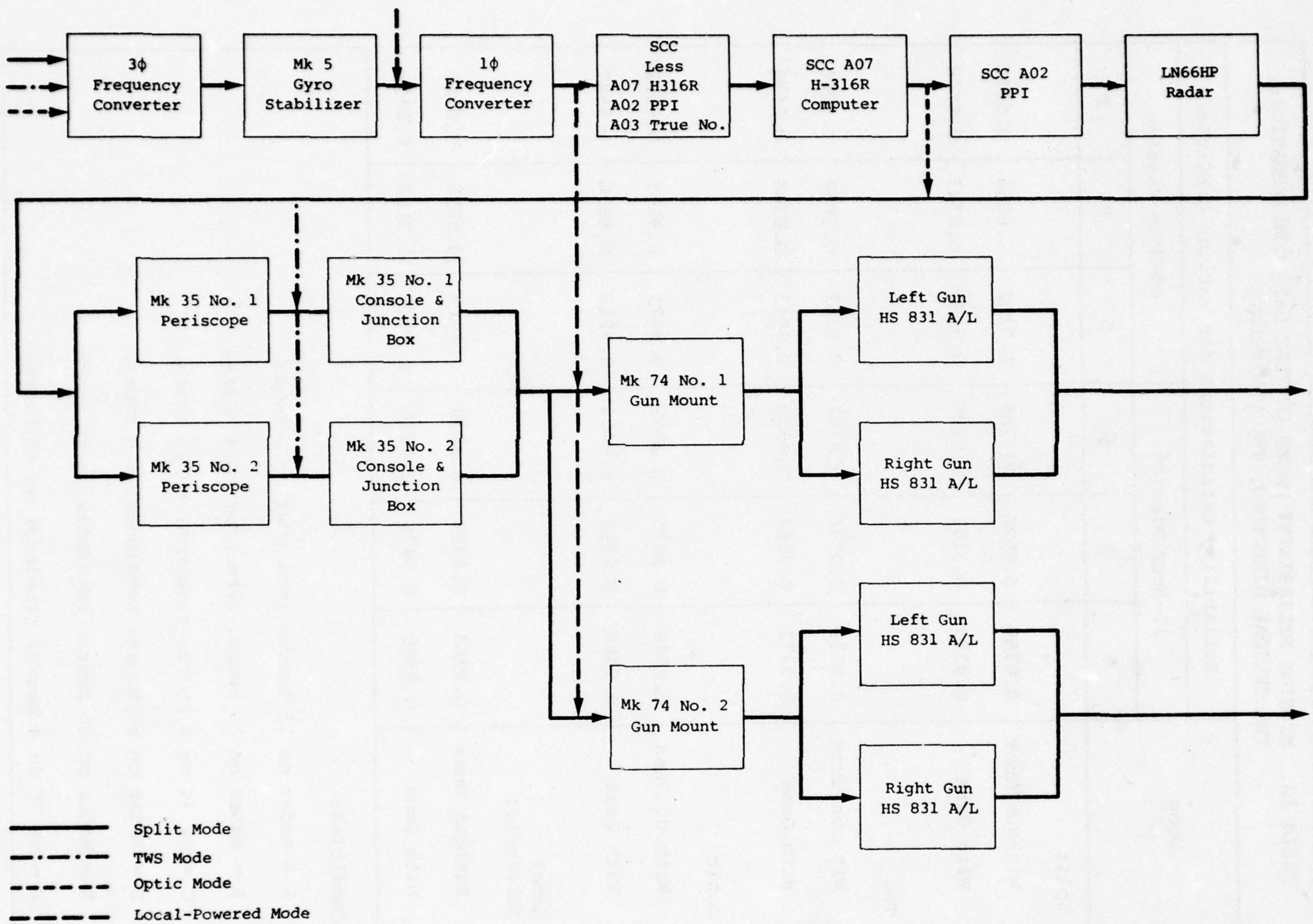


Figure 13. RELIABILITY BLOCK DIAGRAM FOR TWO DIRECTORS AND TWO MOUNTS

CHAPTER FIVE

PRODUCTION-WEAPON-SYSTEM CONSIDERATIONS

The various subsystems of the weapon suite have been discussed and their individual and collective reliability and maintainability assessed. The general items discussed in the following paragraphs are related to the CPIC and will affect the final weapon system's reliability/maintainability/availability (RMA) and influence the Plan for Maintenance (PFM). These items are considered worthy of further discussion and future investigation.

5.1 MISSION SCENARIOS

The definition of the primary employment of the CPIC should be re-evaluated and updated as necessary. To establish the probability of mission success it will be necessary to define the mission clearly. The two extremes would be (1) lengthy (60-hour) patrols with gun action *possible* once at any point in the mission, and (2) a quick-reaction back-up mission in which the craft is deployed for short periods where gun action is *highly probable* and the area of action is well defined. In addition, cycle-time estimates are necessary to predict the probability of a craft's being available for a number of missions in a definite time period.

A predicted threat environment will assist in production-system definition; in particular, the cross section area, speed, and engagement range of both surface and air threats are essential. In addition, the expected and required reaction times for single and multiple threats are needed. These times could be best defined by developing a set of Tactical Operational Requirements (TOR) for the CPIC Weapon System.

The following additional items are important to the mission scenarios:

- A prediction of the number of craft required to assure a long period of operation should be developed.
- The search area that a CPIC can be expected to patrol should be established, with definition of the required revisit time.
- Plans and equipages are required to assist weapon system operators in identifying hostile craft when operating in an area where friendly units are deployed (ESM, IFF, etc.).

- A method is required for keeping track of non-hostile and previously investigated contacts in a search area that will be patrolled for up to 60 hours (status boards, vertical plots, etc.).
- Early warning of pending surface-to-surface missile attack is critical to CPIC survivability. This will require an ESM warning device as a minimum.

5.2 MANNING AND ORGANIZATIONAL MAINTENANCE

The following questions should be answered before a PFM or a spare-parts requirements allocation plan is developed:

- Will the CPIC have a permanent crew with an assigned CO/OIC for each craft, or will the CPIC be operated on a rotating-crew basis?
- What level of actual underway casualty correction is anticipated?
- Will any routine maintenance checks be performed at sea, or is it envisioned that the at-sea patrols are Condition I/II and the crew will be unavailable for non-patrol/non-combat type effort?
- What specialized technical assistance will be available at the CPIC home base? Will the division or unit commander have direct access to maintenance specialists (similar to U.S. Navy MOTU)?
- Will the operating crew have additional housekeeping support in port, or will the craft's cleanliness and preservation be the operating crew's responsibility?
- What system availability is required for CPIC to perform its assigned mission? (Will CPIC ever go on patrol with the weapon system less than fully operational?)

5.3 OVERHAUL CYCLE

It is anticipated that the weapon system will require depot-level overhaul approximately every five years. Present plans call for the craft to undergo a three-week annual overhaul (every 2,500 operating hours).

A lower-level overhaul of the weapon system is planned during the annual craft overhaul. In order to obtain a better parts usage prediction, a detailed plan for this overhaul should be made; in addition, items that can be overhauled and returned to the craft in three weeks and those which must be replaced with like-new systems must be identified. A complete five-year weapon system overhaul plan would permit a more realistic parts-procurement program.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

On the basis that the CPIC operations schedule will require patrols of from 15 to 60 hours with the gun mount used for four hours, it appears that the installed weapon system will fulfill its requirements. A clearly defined threat has not been available; thus it was assumed that the craft would not start an operation for patrol without a completely operational weapon system.

6.2 RECOMMENDATIONS

The following recommendations should be considered prior to the development and delivery of the production model of the CPIC. All recommendations are such that they could be implemented independently, but all are considered necessary to helping the system perform its mission more effectively.

6.2.1 Primary Power Source

At present, the 24-volt battery in the Mk 74 Mod 0 Gun Mount is the primary source of power for charging the guns, operating the feed sub-system motors, firing the guns, and performing other 24-volt mount functions. The circuitry should be changed so that ship's power will be the primary source for performing these functions and the battery can be used as a standby supply if ship's power to the mount is lost. The battery should be located below deck rather than in the mount to provide additional protection from possible battle damage.

6.2.2 HS-831 Maintenance

A variety of failures were encountered during the firing tests performed with the HS-831 30mm guns. These failures ranged from feeder stoppages to broken components. Since the guns are off-the-shelf items of foreign manufacture, there is little that can be done to enhance their reliability for this application. By implementing a program of inspections

and *preventive maintenance*, the probability of gun downtime due to wearout or misalignment of parts can be reduced. The HS-831 A/L instruction manual provides details for disassembly and reassembly of the gun and feeder. On the basis of available test results, the following items should receive special attention:

- Regular replacement of closing springs and tubes.
- Regular replacement of the extractor.
- Regular inspection of oil level in the recoil absorbers.
- Field stripping, cleaning, and inspection of gun and feeder for bent parts, wear, or breakage after each firing. Special attention should be given to determining the presence of foreign materials in the working mechanisms of the gun. A number of stoppages were a direct result of this problem.
- Regular inspection, to quality-control standards, of belt links prior to use in the feed system.

Since the gun design cannot be changed, the mission availability of the gun can most readily be improved by a closely controlled maintenance program. The present instruction manual may have to be supplemented by specific maintenance procedures to be performed at specified intervals.

6.2.3 Periscope Improvement

Certain mechanical elements of the Mk 35 Mod 0 Director periscope assembly can be improved in the production model with minimum design and cost impact. This is especially true with regard to pressurization and component access. A change to a nonpressurized periscope should be investigated.

6.2.4 Alignment Procedures

Weapon system alignment procedures should be refined to ensure the availability of a reliable system under less than ideal conditions, especially the ability to conduct quick, periodic alignment checks.

6.2.5 Optical System Maintenance

Optical system maintenance methods and levels of maintenance must be clearly established on the basis of the user's projected ability, and the necessary special tools must be provided.

6.2.6 H316R Computer Replacement

Consideration should be given to replacing the H316R computer with a more modern computer that will be more reliable and more easily supported (AN/UYK-20 or similar). A cost-trade-off analysis of the computer change would be required prior to such a decision since reprogramming would almost certainly be necessary if another computer were used.

6.2.7 Wind-Measurement Capability

Wind speed and direction are required inputs for the fire-control solution; yet the CPIC has no wind indicator or measuring device. A relative-wind-measuring device should be installed in the CPIC, with read-out available at the SCC.

6.2.8 Technician Theoretical Depth

All organizational/intermediate/depot-level maintenance technicians should have a good background in electronic theory, with an emphasis on radar theory.

6.2.9 Power Supply Reliability

The criticality of the 400-Hz power to the operation of the weapon system requires the highest level of reliability for the power supply. Since the space and weight requirements of the craft will probably preclude redundant/back-up 400-Hz sources, the production-craft source must be selected with care. The total craft power requirements should be reviewed and an optimum source and distribution system identified. This source may be the present two converters or possibly a single three-phase converter.

6.2.10 Stabilization

The Mk 5 Mod 0 presents no apparent problems for use in the CPIC, but it may be advisable to consider a more modern stabilizer system in order to conserve space and weight. The Mk 5 occupies approximately five cubic feet and weighs 106 pounds. In addition, the electronic tube controller unit could be replaced by a solid-state unit, which might be more easily maintained at the organization level. In addition, as discussed in the director analysis (Section 3.2.2), it may be desirable to use this stabilizer to stabilize the director optics in lieu of a separate director gyro system.

6.2.11 Change Control

In the weapons system specifications for the production CPIC, close control must be exercised over any equipment changes and a system of monitoring change proposals instituted early in the program to ensure the interchangeability of subsystems and the availability of repair parts.

6.2.12 Documentation

The maintainability and, ultimately, the reliability of a complex weapon system are highly dependent upon the documentation and maintenance procedures provided. The CPIC prototype weapon system includes interim MIPs and MRCs for the Mk 35 Director, Mk 93 SCC, and Mk 74 Gun Mount. It is essential that MRCs be developed for the remainder of the weapon system, in particular the HS-831 A/L guns, which will require proper preventive maintenance to ensure reliability.

APPENDIX A

DERIVATION OF GUN RELIABILITY EQUATION

APPENDIX A

DERIVATION OF GUN RELIABILITY EQUATION

The reliability equation was derived as follows: assuming that both guns are firing simultaneously, determine the probability that a 500-round firing mission can succeed. One mode of success is that each gun fires 250 rounds, and the probability that this will occur is expressed by

$$R = R_{250} \cdot R_{250}$$

where R_{250} is the probability that one gun fires 250 rounds.

Throughout this discussion R_i represents the probability of a single gun's completing the firing of i rounds; for example,

R_{500} is the probability that one gun fires 500 rounds

R_1 is the probability that one gun fires 1 round

The other modes of success are:

$$R = R_{250} \cdot R_{249} \cdot (1 - R_1) \cdot R_{[500 - (500 - 1)]}$$

$$R = R_{249} \cdot R_{248} \cdot (1 - R_1) \cdot R_{[500 - (498 - 1)]}$$

$$\vdots$$

$$R = R_1 \cdot R_0 (1 - R_1) \cdot R_{[500 - (2 - 1)]}$$

Since either gun is assumed to be able to complete the total 500-round firing mission, given that the other gun failed prior to 250 rounds, this series can occur in two ways. The general expression then becomes

$$R = (R_{250})^2 + 2 (1 - R_1) \sum_{i=1}^{250} R_i R_{i-1} R_{[500 - (2i - 1)}$$

Since

$$R_i R_{i-1} R_{[500 - (2i - 1)]} = R_{500}$$

for all i under the assumption that the probability of any single successful firing remains constant, the equation becomes

$$R = (R_{250})^2 + 500 R_{500} (1 - R_1)$$

APPENDIX B

SUMMARY OF CPIC WEAPON
SYSTEM FAILURE DATA

Preceding Page Blank - Filmed

Subsystem/Element	Failures	Operating Time (Hours)	MTBF (Hours)	λ (Failures/Operating Hours, x 10^{-6})	Casualty Description and Remarks	Date	Location
SYSTEM CONTROL CONSOLE			161	6209.54	Includes AØ1 thru All ($\lambda = \sum \lambda_i$)		
AØ1 (TGT and Director)	-				Switch (Dir. 2/Off TDS) - Not Critical	1-15-73	OSSIT
	-				Switch (Dir. 2 TWS 1) - Not Critical	5-14-73	OSSIT
	1				Switch (Dir. 2 TMA)	7-16-73	OSSIT
	-				Broken Wire Computer Interface Cable - Installation Problem	11-1-73	At-Sea
					Loose Pin in TWS Connector - Maintenance Problem	1-21-74	At-Sea
Total AØ1	1	1823	1823	548.55			
AØ3 (True North)	-				Spoking on PPI - Maintenance Problem	-	At-Sea
AØ4 (Mount and Status)	1	1823	1823	548.55	TWS Threshold Pot	5-30-73	OSSIT
AØ6 (Converter)	1	1823	1823	548.55	Synchro to Digital Converter	-	At-Sea
AØ7 (Computer)	-				Register Switch/Power Supply - Not Critical	4-9-73	OSSIT
	-				Back Plane Pins Touching - Not Critical	4-27-73	OSSIT
	1				Line Driver Card	6-23-73	OSSIT
	1				Priority PAC Card	6-25-73	OSSIT
	1				M-Register Card	7-11-73	OSSIT
	4				Intermittent Failures of Greater Than Four Hours Duration	4-7-73	OSSIT
	1				PC Card CM022	10-25-73	At-Sea
	1				PC Card TG335	10-30-73	At-Sea
	-				Unable to Load Program Using Paper Tape Reader - Not Critical	10-31-73	At-Sea
	-				Broken Ground Wire at Connector Paper Tape Reader - Not Critical	11-1-73	At-Sea
Total AØ7	9	1972	219	4563.89			
AØ9 (Swbd & Power Sup.)	-				5V Logic Power Supply-Cooling System Changed	5-19-73	OSSIT

SUMMARY OF FAILURE DATA

Subsystem/Element	Failures	Operating Time (Hours)	MTBF (Hours)	λ (Failures/Operating Hours, x 10^{-6})	Casualty Description and Remarks	Date	Location
LN 66 HP RADAR	1	1823	1823	548.55	Excluding PPI (AØ2 of SCC)		
Antenna	-				Intermittent Ships Head Marker - Maintenance Error	1-28-74	At-Sea
T/R Unit	-				Radar Detector Crystal - Maintenance Error	11-11-73	OSSIT
	1				Pulse Change Relay Hangs in Wide Pulse Position	1-28-74	At-Sea
Total T/R Unit	1	1823	1823	548.55			
Frequency Converter 100-153	7	589	84	11884.55	1ϕ, 5KW, 400 H. Converter		
Converter	1				Blown Fuse, F-1	10-26-73	At-Sea
	1				Blown Fuse, F-1	10-27-73	At-Sea
	1				Blown Fuse, F-1	11-2-73	At-Sea
	1				Blown Fuse, F-1	11-5-73	At-Sea
	1				Blown Fuse, F-1	11-6-73	At-Sea
	1				Blown Fuse, F-1 (PCB A-2)	12-1-73	At-Sea
	1				Blown Fuse, F-1 (PCB A-4, L1-4)	1-29-74	At-Sea
Total Converter	7	589	84	11884.55			

SUMMARY OF FAILURE DATA (continued)

Subsystem/Element	Failures	Operating Time (Hours)	MTBF (Hours)	$\hat{\lambda}$ (Failures/Operating Hours, x 10^{-6})	Casualty Description and Remarks	Date	Location
MK 74 Gun Mount	1	108	108	9259.26			
Train Drive	-				Excessive Train Bearing Friction - Installation Problem	9-11-72	OSSIT
	-				Magnetic Clutch - Redesigned	5-23-73	OSSIT
Electronic Comp.	-				Power Amp. and Power Supply - Redesigned	2-19-73	OSSIT
	-				Power Amplifier - Redesigned	2-23-73	OSSIT
	-				Power Amplifier - Redesigned	2-27-73	OSSIT
Power Battery	-				On-Mount Battery (NICAD) - Maintenance Problem	6-27-73	OSSIT
Cabin	-				Door Fasteners - Not Critical	8-12-72	OSSIT
	-				Broken Door Hinges - Redesigned	11-7-73	At Sea
Sighting Station	-				Local Sighting Station 2 Support Bolts Sheared in High Sea State Operations - Redesigned	1-10-74	At Sea
DE-ICE	-				440 V, 60H, , 3ϕ Circuit Breaker Activated - Redesigned	-	At Sea
Ammo. Feed	-				Booster Motor Miswired - Assembly Error	12-19-72	OSSIT
	1				Burned Out Motor Due to Low Voltage	12-19-72	OSSIT
Total Ammo. Feed	1	108	108	9259.26			

SUMMARY OF FAILURE DATA (continued)

Subsystem/Element	Failures	Operating Time (Hours)	MTBF (Hours)	$\hat{\lambda}$ (Failures/Operating Hours, x 10^{-6})	Casualty Description and Remarks	Date	Location
MK 35 Director No. 1	1	1083	1083	923.36	Includes Periscope, Console and ½ Junction Box		
Periscope	-				Elevation Binding - Installation Error	11-16-72	OSSIT
	1				Day-Night Mode Handle	12-18-72	OSSIT
	-				Head Window Cracked - Design Change	12-23-72	OSSIT
	-				Leaking Head Window - Excessive Environmental Condition	6-19-73	OSSIT
Total Periscope	1	1083	1083	923.36			
Console Assy.	-				Lamp Dimmer CKT. Transistors - Not Critical	11-13-73	At Sea
MK 35 Director No. 2	3	754	251	3978.78	Includes Periscope, Console and ½ Junction Box		
Periscope	-				Slipped Derotation Synchro - Not Critical	10-25-73	At Sea
Console Assy.	1				ON/NAV Switch	1-17-73	OSSIT
	1				Bad Resistor/Broken Conductor in 300 Board	2-18-73	OSSIT
	-				Dimmer CKT. Potentiometer - Not Critical	3-6-73	OSSIT
	1				Elevation Operational Amplifier MA-1	1-16-74	At Sea
Total Console	3	754	251	3978.78			

SUMMARY OF FAILURE DATA (continued)

APPENDIX C

RELIABILITY PREDICTION
FOR
SYSTEM CONTROL CONSOLE

Condition 1: T_a = 30°C (86°F)

Condition 2: T_a = 65°C (149°F)

Preceding Page Blank - Filmed

COMPONENT	NUMBER	FAILURE DATA USED		SOURCE
		CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	
Amplifier				
Differential	HA-2-2520	6.00	6.00	Hdbk-217A;pg. 7.14-6A; (Note 1)
Operational	SN72741L	6.00	6.00	
	SN72301L	6.00	6.00	
	M38510/10101CCB	6.00	6.00	
Assembly, Readout		0.350	0.350	Honeywell Estimate
Backwire Plane	1047	1.2	1.2	
Blower	ST682-YS	2.25	2.25	
Board				
PC	160_ -801	.17	.17	
Stitchwire		.17	.17	
Terminal	37TB16			
Breaker, Circuit	M39019/3	. 5	. 5	Hdbk-217A; pg. 7.12-3 (Note 2)
Capacitor				
15μF	CSR13E156KM	.33	.65	Hdbk-217A; pg. 7.6-77 (Note 3)
	CS13B		.65	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED		SOURCE
		CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	
18µF /50V	M39003/01-2619	.33	.65	
100µF /10V	M39003/01-2502	.33	.65	
.033µF	CK06BX333K	0.109	0.32	Hdbk-217A; pg 7.6-57 (Note 4)
.0022µF	CK06BX22K	0.109	0.32	
.1µF/100V	CK06BX104K	0.109	0.32	
.01µF	CKR06CW103MP	0.109	0.32	
	CK05	0.109	0.32	
	CK06BX472K	0.109	0.32	
5PF	CM05CD050DP3	0.024	0.039	Hdbk-217A; pg 7.6-21 (Note 5)
10 PF	CM05CD100DP3	0.024	0.039	
47PF	CM05ED470JP3	0.024	0.039	
Circuit, Delay	7119	0.15	0.15	Honeywell Estimate
Circuit, Integrated				
	SN52510AJ	6.0	6.0	Hdbk-217A; pg. 7.14-6A (Note 1)
	SN5400J	6.0	6.0	
	SN5404J	6.0	6.0	
	SN5406J	6.0	6.0	
	SN5410J	6.0	6.0	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Circuit, Integrated (Cont'd)				
	SN5437J	6.0	6.0	
	SN5440J	6.0	6.0	
	SN5483AJ	6.0	6.0	Hdbk-217A;pg. 7.14-6A (Note 1)
	SN54L85J	6.0	6.0	
	SN54107J	6.0	6.0	
	SN54123J	6.0	6.0	
	SN54154J	6.0	6.0	
	SN54157J	6.0	6.0	
	SN54161J	6.0	6.0	
	SN54164J			
	SN54174J	6.0	6.0	
	SN54175J	6.0	6.0	
	SN54191J	6.0	6.0	
	SN54197J	6.0	6.0	
	SN54S112J	6.0	6.0	
	SN55107J	6.0	6.0	
	SN55110J	6.0	6.0	
	SN7404J	6.0	6.0	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Circuit, Integrated (Cont'd)	SN7406J	6.0	6.0	
	SN7410J	6.0	6.0	
	SN7416J	6.0	6.0	
	SN7474J	6.0	6.0	
	SN74193J	6.0	6.0	Hdbk-217A; pg. 7.14-6A (Note 1)
	DM7214D	6.00	6.0	
	ITT9465D	6.00	6.0	
	U6A7741393	6.00	6.0	
	U6A993659X	6.00	6.4	
LSI	TMS3112JC	4.84	4.84	Honeywell Estimate
Connector				
	1081	0.06	0.06	Honeywell Estimate
	1856	0.06	0.06	
	202515-3	0.008	0.008	
	202516-3	0.008	0.008	
	204259-2	0.021	0.021	
	204260-2	0.021	0.021	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Connector (Cont'd)				
	6-204692-6	0.06	0.06	
	204693-6	0.06	0.06	
	204738-2	0.014	0.014	
	204739-2	0.014	0.014	
	204749-2	0.014	0.014	
	901-535	0.003	0.003	
	00-7008-141-156-003	0.06	0.06	
	00-7008-141-159-002	0.014	0.014	
	10-521-807-107	0.061	0.061	
	10-521-810-19	0.006	0.006	
	10-521-810-27P	0.008	0.008	
	10-521-810-275	0.008	0.008	
	10-521-816-53	0.014	0.014	
	10-521-817-52	0.014	0.014	
	MS3402D18-11	0.003	0.003	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED: CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED: CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Connector (Cont'd)				
	MS3402D20-27	0.008	0.008	
	MS3402D28-21	0.006	0.006	
	MS3402D36-10	0.003	0.003	
	MS3402D40-56	0.015	0.015	
	MS90335-5	0.003	0.003	
100 Pin ELCO		0.06	0.06	
41 Pin Type		0.014	0.014	
Connector, Relay	VBB/1PA/1-45	0.001	0.001	
Converter				
A/D	ADC40-12-B1N	16.8	16.8	Honeywell Estimate
D/A	DAC40-12U-CB1	20.0	20.0	
Counter	4Y-8829-6	0.254	0.254	
Degree	3Y-9992-R	0.254	0.254	
Rounds	EVS15.11	4.20	4.20	
Diodes				
Light Emitting	2LRSRTLFL5/15	1.0	1.0	ARINC Estimate
Silicon Signal	JAN1N645	3.16	4.33	Hdbk-217A;pg.7.4-11 (Note 6)

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Diodes (Cont'd)				
	JAN1N4245	3.26	6.43	Hdbk-217A;pg 7.4-11 (Note 7)
	JAN1N4454	1.86	2.77	(Note 8)
Switching	JAN1N914	1.86	2.95	(Note 9)
Zener	JAN751A	3.08	4.92	(Note 10)
	JAN1N753A	3.08	4.92	
	JAN1N3022A	3.71	5.73	(Note 11)
	JAN1N3022BS	3.71	5.73	
	JAN1N3826A	3.71	5.73	
Encoder, BCD Shaft	SNB-13P20	3.0	3.0	Honeywell Estimate
Filter, RFI	GF-4500-13,14,17	0.438	0.438	Honeywell Estimate
Flasher	F945	12.5	12.5	
Gear Train				
Range	1099	0.9	0.9	
Bearing	1098	0.9	0.9	
Indicator	800-5-A2C2-J3-L2-N2	1.631	1.631	
Jack, Test	M37010035			
Magslip	314-188888-001	2.4	2.4	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Meter, Time Totalizing	MS17325-5	1.48	1.48	Hdbk-217A;pg.7.8-9 (Note 12)
Panel, Edge Lit	1050/1051	1.0	1.0	Honeywell Estimate
Power Supply				
2901-1	37656742-01	54.0	54.0	
2901-2	37656742-02	27.0	27.0	
Relay				
Time Delay	DOC-2-A-3-A-1	11.44	11.44	Hdbk-217A;pg.7.10-5 (Note 13)
Reed	PRME1A005B	0.00215	0.0215	(Note 14)
	M5757/9-031	.572	.572	(Note 15)
	M5757/16-003	.572	.572	
	M5757/19-019	.572	.572	
	M5757/23-004	.572	.572	
	M5757/23-005	.572	.572	
	MS27418-1B	.572	.572	
Resistor Network				
1000 Ω	D14M-01-102J	.65	.65	Honeywell Estimate

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Resistor, Fixed Cont d				
3300	D14M-01-332J	.65	.65	Honeywell Estimate
Fixed				
	RBR52...	.87	1.03	Hdbk-217A; pg.7.5-19 (Note 16)
1000Ω, 1/8W	RCR05G102JS	.0742	.3	(Note 17)
10KΩ	RCR05G103J	.0742	.3	
1500 Ω	RCR05G152J			
150KΩ	RCR05G154J	.0742	.3	
1600Ω	RCR05G162J			
16KΩ, 1/8W	RCR05G163J	.0742	.3	
200Ω	RCR05G201J	0.0742	0.3	
2KΩ	RCR05G202J	0.0742	0.3	
2.2KΩ	RCR05G222J	0.0742	0.3	
300 Ω	RCR05G301J	0.0742	0.3	
3300Ω	RCR05G332J	0.0742	0.3	
39Ω	RCR05G390J	0.0742	0.3	
470Ω	RCR05G471J	0.0742	0.3	
4700 Ω	RCR05G472J	0.0742	0.3	

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Resistor,Fixed Cont'd				
5KΩ	RCR05G502J	0.0742	0.3	
510Ω, 1/8W	RCR05G511J	0.0742	0.3	
5100Ω	RCR05G512J	0.0742	0.3	
5600Ω	RCR05G562J	0.0742	0.3	
62Ω, 1/8W	RCR05G620JS	0.0742	0.3	
7500Ω, 1/8W	RCR05g752J	0.0742	0.3	
2.7Ω	RCR07G2R7J	0.0742	0.3	
10Ω	RCR07G100J	0.0742	0.3	
100Ω	RCR07G101J	0.0742	0.3	
100Ω, 1/4W	RCR07G101JS	0.0742	0.3	
120Ω	RCR07G121J	0.0742	0.3	
130Ω	RCR07G131J	0.0742	0.3	
150Ω	RCR07G151J			
15KΩ	RCR07G153J			
220Ω	RCR07G221J			
2.7MΩ, 1/4W	RCR07G275JM			
47Ω	RCR07G470J			

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED		
		CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Resistor, Fixed (Cont'd)				
62Ω, 1/4W	RCR07G620J			
68Ω	RCR07G680J			
2.7Ω	RCR20G2R7J			
150Ω, 1W	RCR32G151J			
	RLR07...	0.2898	0.52	Hdbk-217A; pg.7.5-33 (Note 18)
10KΩ, 1/4W	RLR07103JM			
110KΩ, 1/4W	RLR07104JM			
27KΩ, 1/4W	RLR07C273JM			
	RN65	0.1005	0.15	Hdbk-217A; pg.7.5-25 (Note 19)
	RNC55			
5110Ω	RNC55J5111FM			
	RNG5			
4.02Ω	RWR74S4R02FM	0.56	0.78	Hdbk-217A; pg. 7.5-15 (Note 20)
1.62Ω	RWR78S1R62FM	0.56	0.78	
2.37Ω	RWR78S2R37FM			
0.147Ω	RWR80SR147FM			
0.187Ω	RWR80SR187FM			

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Resistor, Fixed (Cont'd)				
0.59Ω	RWR80SR590FM			
0.787Ω	RWR80SR787FM			
0.226Ω	RWR89SR226FM			
0.332Ω	RWR89SR332FM			
Variable				
10KΩ	RT26C2P103	0.924	1.18	Hdbk-217A; pg 7.5-35 (Note 21)
500Ω	76PR500(RTR...)			
2KΩ	76PR2K RTR12DP202R			
Switch				
Linear	1853048	4.756	4.756	Honeywell Estimate
Push Button	800-5-A3C2E4-L2	0.192	0.192	Hdbk-217A; pg.7-10-7 (Note 22)
Rotary				
	JV9032	0.216	0.216	Hdbk-217A; pg. 7-10-7 (Note 23)
	S2JM-15	0.216	0.216	
	S3JR-15	0.216	0.216	Hdbk-217A; pg.7-10-7 (Note 23)
Thumbwheel	7-H-219,220	3.0	3.0	Honeywell Estimate

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

COMPONENT	NUMBER	FAILURE DATA USED CONDITION 1 $\lambda \times 10^{-6}$ $T_a = 30°C$	FAILURE DATA USED CONDITION 2 $\lambda \times 10^{-6}$ $T_a = 65°C$	SOURCE
Switch (Cont'd)				
Toggle	MS35059-_	0.144	0.144	Hdbk-217A; pg. 7.10-7 (Note 24)
	MS27718-23	0.144	0.144	
357		0.144	0.144	
Torgsyn	VTSN23	11.12	11.12	Honeywell Estimate
Transformer	PAB-619	0.194	0.194	Hdbk-217A; pg. 7.7-9 (Note 25)
	HSM-200	0.194	0.194	
Transistor, Si				
NPN	JAN2N2219	0.45	0.70	Hdbk-217A; (Note 26)
	JAN2N2222A	0.45	0.70	Hdbk-217A; (Note 27)
	JAN2N3501	0.45	0.66	Hdbk-217A; (Note 28)
PNP	JAN2N2905	1.38	3.15	Hdbk-217A; (Note 29)
	JAN2N2907A	1.38	3.15	Hdbk-217A; (Note 30)
	JAN2N4007	1.38	3.15	
Power $\geq$ 1	JAN2N3766	0.459	0.77	Hdbk-217A; (Note 31)
Wind Data Input Module		3.0	3.0	Honeywell Prediction

RELIABILITY PREDICTION FOR SYSTEM CONTROL CONSOLE

APPENDIX C

SOURCE DATA NOTES

NOTE: 1 - $\lambda_B = 0.4$; $K = 3.0$; QF=5

2 - Table VII - XXVI; CB - Magnetic

3 - Level M; SR= 0.5, $T_a = 30^\circ C$, $\lambda_B = 0.33$, K= ---;
SR = 0.5, $T_a = 65^\circ C$, $\lambda_B = 0.65$, K = ---

4 - SR = 0.5, $T_a = 30^\circ C$, $\lambda_B = 0.0065$, K = 16.8;
SR = 0.5, $T_a = 65^\circ C$, $\lambda_B = 0.019$; K = 16.8

5 - SR = 0.5, $T_a = 30^\circ C$, $\lambda_B = 0.0021$, K = 11.5
SR = 0.5, $T_a = 65^\circ C$, $\lambda_B = 0.0034$, K = 11.5

6 - $\Theta_{J-A} = 3.2\ mW/^\circ C$, $P_{J\ max} = 0.6W$, $T_{J\ max} = 150^\circ C$,
$\lambda_B = 0.73$, K = 4.33

7 - $\Theta_{J-A} = 0.1875\ ^\circ C/mW$, $P_{Jmax} = 0.8W$, $T_{Jmax} = 175^\circ C$,
$\lambda_B = 1.0$, K = 3.26

8 - $\Theta_{J-A} = 2.85\ mW/^\circ C$, $P_{Jmax} = 0.5W$, $T_{Jmax} = 200^\circ C$,
$\lambda_B = 0.43$, K = 4.33

9 - $\Theta_{J-A} = 1.67\ mW/^\circ C$, $P_{Jmax} = 250\ mW$, $T_{Jmax} = 175^\circ C$
$\lambda_B = 0.43$, K = 4.33

10 - $\Theta_{J-A} = 3.2\ mW/^\circ C$, $P_{Jmax} = 0.4\ W$, $T_{Jmax} = 175^\circ C$
$\lambda_B = 1.12$, K = 2.75

11 - $\Theta_{J-A} = 6.67\ mW/^\circ C$, $P_{Jmax} = 1.0\ W$, $T_{Jmax} = 175^\circ C$
$\lambda_B = 1.35$, K = 2.75

12 - Table VII - XXIII, AC, $\lambda_B = 20$, K = 0.148,
$T_a/T_{max} = 0.5$

13 - Type N, $\lambda_B = 0.02$, K = 286, $GF_c = 2.0$

14 - Type F, $\lambda_B = .05 \times 10^{-4}$, K = 286, $GF_c = 1.5$

15 - Type J, $\lambda_B = 0.001$, K = 286, $GF_c = 2.0$

SOURCE DATA NOTES

Note: 16 - SR = 0.5, T_a = 30°C, λ_B = 1.00, K = 0.87;
SR = 0.5, T_a = 65°C, λ_B = 1.19, K = 0.87

17 - SR = 0.5, T_a = 30°C, λ_B = 0.0035, K = 21.2;
SR = 0.5, T_a = 65°C, λ_B = 0.014, K = 21.2

18 - SR = 0.5, T_a = 30°C, λ_B = 0.210, K = 1.38;
SR = 0.5, T_a = 65°C, λ_B = 0.38, K = 1.38

19 - SR = 0.5, T_a = 30°C, λ_B = 0.15, K = 0.67;
SR = 0.5, T_a = 65°C, λ_B = 0.23, K = 0.67

20 - SR = 0.5, T_a = 30°C, λ_B = 0.020, K = 28;
SR = 0.5, T_a = 65°C, λ_B = 0.028, K = 28

21 - SR = 0.5, T_a = 30°C, λ_B = 46.2, K = 0.02;
SR = 0.5, T_a = 65°C, λ_B = 59.0, K = 0.02

22 - Type A, λ_B = 0.1, K = 0.96, GF_c = 2.0

23 - Type H, λ_B = 0.075, K = 0.96, GF_c = 3.0

24 - Type F, λ_B = 0.03, K = 0.96, GF_c = 5.0

25 - Class A, T_{max} = 75°C, λ_B = 0.20, K = 0.97

26 - Θ_{J-A} = 5.33 mW/°C, P_{Jmax} = 0.8W, T_{Jmax} = 175°C;
λ_B =0.44, K = 1.03

27 - Θ_{J-A} = 3.33 mW/°C, P_{Jmax} = 0.5 W, T_{Jmax} = 175°C
λ_B = 0.44, K = 1.03

28 - Θ_{J-A} = 5.71 mW/°C, P_{Jmax} = 1.0W, T_{Jmax} = 200°C
λ_B = 0.44, K = 1.03

SOURCE DATA NOTES

Note 29 - Θ_{J-A} = 3.43 mW/$^{\circ}$C, P_{Jmax} = 0.6W, T_{Jmax} = 200°C

λ_B = 1.34, K = 1.03

30 - Θ_{J-A} = 2.28 mW/$^{\circ}$C, P_{Jmax} = 0.4W, T_{Jmax} = 200°C

λ_B = 1.34, K = 1.03

31 - Θ_{J-A} = 16 mW/$^{\circ}$C, P_{Jmax} = 2.0W, T_{Jmax} = 150°C

λ_B = 0.9, K = 0.51

INHERENT RELIABILITY ANALYSIS WORKSHEET

Summary Sheet

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___
CPi	RGFCS	SCC					

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
A01	Tgt & Dir (L. Drawer)									2350.553		2433.2186		
A02	PPI													
A03	True North									13.528		13.528		
A04	Mt. & Status (R. Drawer)									215.0306		279.389		
A05	Sys. Status (Control Panel)									60.343		60.343		
A06	Upper Converter									2732.094		3658.822		
A07	Computer									540.18		540.18		
A08	Lower Converter									2732.094		3658.822		
A09	Xbd & Power Supply									112.356		225.056		
A10	R. Rear Conn. (L. I/O Panel)									2.742		2.742		
A11	L. Rear Conn. (R. I/O Panel)									0.093		0.093		
	Door Assembly									4.579		4.579		
	Cable Harness									1.299		1.299		
	RF Plumbing									28.389		28.384		
CONDITION 1			CONDITION 2						SUM OF NKλ	[illegible]73.2806	SUM OF NKλ	10936.4608		

INHERENT RELIABILITY ANALYSIS WORKSHEET

A01 - Summary Sheet

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
EPIC	RGFCS	SCC - A01	A01	Target & Director (Left Drawer)			1 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
Basic	Panel									94.543		113.263		
A01	I/O Control Sequencer									194.7722		201.10		
A02	Director Brg. Error Generator & Buffer									189.3264		197.22		
A04	I/O Data Select/Buffer									100.6704		109.06		
A05	I/O 16 Bit 4 to 1 Multiplexer									54.887		55.84		
A06	Same as A05									54.887		55.84		
A07	Same as A05									54.887		55.84		
A08	Same as A05									54.887		55.84		
A09	I/O Test Interface									135.49455		142.38215		
A10	Pit Log Interface									126.4056		137.22		
A12	TWS Brg. Cursor & Test Tgt. Generator									194.2512		216.43		
A13	TWS 2 Target Position Computer									190.0122		197.34		
A14	TWS 1 Target Position Computer									190.0122		197.34		
A15	TWS Clock & Range Ring Generator									157.5108		160.00		----
CONDITION 1		CONDITION 2							SUM OF NKλ		SUM OF NKλ			

AD-A054 034 ARINC RESEARCH CORP ANNAPOLIS MD F/G 19/6
ENGINEERING ASSESSMENT OF COASTAL PATROL AND INTERDICTION CRAFT--ETC(U)
SEP 74 J D BROGLIO, G P METTLER, A N WINTER N00197-74-C-0506

UNCLASSIFIED 1625-01-1-1353 NL

2 OF 2
AD
A054034

END
DATE
FILMED
6-78
DDC

INHERENT RELIABILITY ANALYSIS WORKSHEET

A01 - Summary Sheet

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC					2 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
A17	TWS 1 Range & Bearing Window Generator									199. 3276		201. 38		
A18	TWS 2 Range & Bearing Window Generator									199. 3276		201. 38		
A19	Strobe Buffer									18. 887		19. 84		
A20	I/O Storage Buffer									140. 46125		145. 90365		

CONDITION 1	CONDITION 2	SUM OF NKλ	SUM OF NKλ
		2358. 553	2463. 2180

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01 | UNIT: Basic Panel | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	A21-29,33-35	Assembly, Readout	351-255-48	11						0.35	3.85	0.35	3.85		
	A30-37, A40-44	Switch	800-5-A3C2E4-L2.	14					0.96	0.192	2.688	0.192	2.688		
	J6	Connector	204738-2	1						0.014	0.014	0.014	0.014		
	J9,10, 11	Connector	MS90335-5	3						0.003	0.009	0.003	0.009		
	P7,8	Connector	204749-2	2						0.014	0.028	0.014	0.028		
	P9-44	Connector	901-535	36						0.003	0.108	0.003	0.108		
	XDS3-5,7-9	Indicator	800-5-A2C2-J3-L2-N2-...	6						1.631	9.786	1.631	9.786		
	CR1-16	Diodes	JAN1N645	16					4.33	3.16	50.56	4.33	69.28		
*		Panel, Edge Lit	1050/1051	3						1.00	3.00	1.00	3.00		
*	K1,2	Relay, Time Delay	D0C-2-A-3-A-1	2					286.	11.44	22.88	11.44	22.88		
*		Backwire Plane	1047	1						1.2	1.2	1.2	1.2		
*	J1-5, 7,8	Connector	6-204693-6	7						0.06	0.42	0.06	0.42		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 94.543 | SUM OF NKλ: 113.263

*Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A01A01	UNIT I/O Control Sequencer	ASSEMBLY	SUBASSEMBLY										SHEET 1 OF 1
IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE		
B1,4,C2, E2,3,F3,4	Circuit, Integrated	SN5400J	7					3	6.0	42.00	6.0	42.00				
B2	Circuit, Integrated	SN5440J	1					3	6.0	6.00	6.0	6.00				
B3,D2,F2, E3,4,F5,6	Circuit, Integrated	SN5404J	7					3	6.0	42.00	6.0	42.00				
C1,D1,E1, E7,F7	Circuit, Integrated	SN54107J	5					3	6.0	30.00	6.0	30.00				
C3,A7, D3,6,7	Circuit, Integrated	SN54197J	6					3	6.0	36.00	6.0	36.00				
C4,F1	Circuit, Integrated	SN54157J	2					3	6.0	12.00	6.0	12.00				
D4	Circuit, Integrated	SN5483J	1					3	6.0	6.00	6.0	6.00				
H1,6,7	Circuit, Integrated	SN54154J	3					3	6.0	18.00	6.0	18.00				
R1-19	Resistor, Fixed 62Ω 1/8W	RCR05G 620J	19			.5		21.2	.0742	1.4098	0.3	5.70				
R20,21	Resistor, Fixed 1000Ω 1/8W	RCR05G 102J	2			.5		21.2	.0742	.1484	0.3	0.60				
C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5		-	0.33	.33	0.65	0.65				
C2-7	Capacitor, Fixed, .033μF	CK06BX 333K	6			.5		16.8	0.109	.654	0.32	1.92				
*	Board, Stitchwire		1						0.17	.17	0.17	0.17				
*	Connector	100 Pin ELCO	1						0.06	.06	0.06	0.06				
CONDITION 1			CONDITION 2						SUM OF NKλ	194.7722	SUM OF NKλ	201.1				

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01A02 | UNIT: Dir Brg. Error Gen. & Buffer | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
B5	Circuit, Integrated	SN54107J	1					3.	6.0	6.00	6.0	6.00		
C2,4,6,D4 H1,2,6,7	Circuit, Integrated	SN5404J	8					3.	6.0	48.00	6.0	48.00		
C3,5 D3,5	Circuit, Integrated	SN54174J	4					3.	6.0	24.00	6.0	24.00		
D1,7	Circuit, Integrated	SN5485J	2					3.	6.0	12.00	6.0	12.00		
D2,6,E1 7,F1,7	Circuit, Integrated	SN5483J	6					3.	6.0	36.00	6.0	36.00		
E2-6 F2-6	Circuit, Integrated	SN54157J	10					3.	6.0	60.00	6.0	60.00		
R1-26	Resistor, Fixed, 62Ω 1/8W	RCR05G 620JS	26			.5			.0742	1.9292	0.3	7.8		
R27	Resistor, Fixed, 1000Ω 1/8W	RCR05G 102JS	1			.5			.0742	.0742	0.3	0.3		
C1	Capacitor, Fixed, 15μF	CSRBE 156KM	1			.5			0.33	.33	0.65	0.65		
C2-8	Capacitor, Fixed, .033μF	CK06BX 333K	7			.5			0.109	.763	0.32	2.24		
*	Board, Stitchwire		1						0.17	.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	.06	0.06	0.06		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 189.3264 | SUM OF NKλ: 197.22

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01A04 | UNIT: I/O Data Select/Buffer | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	COND. 1 BASE λ	COND. 1 TOTAL NKλ	COND. 2 BASE λ	COND. 2 TOTAL NKλ	PERCENT	DATA SOURCE
	E1,2 F1,2, F6,7, H6,7	Circuit, Integrated	SN54157J	8					3.	6.0	48.00	6.0	48.00		
	E3-6, F3-5, H5	Circuit, Integrated	SN5404J	8					3.	6.0	48.00	6.0	48.00		
	H1,2	Resistor, Fixed, 1000 Ω	D14M-01-102J	2			.5	30		0.65	1.3	0.65	1.3		
	R1-16	Resistor, Fixed, 62 Ω, 1/8 W	RCR05G 620J	16			.5	30	21.2	0.0742	1.1872	0.3	4.8		
**	R17-32	Resistor, Fixed, 1000 Ω, 1/8 W	RCR05G 102J	16			.5	30	21.2	0.0742	1.1872	0.3	4.8		
	C1	Capacitor, Fixed, 15 µF	CSR13E 156KM	1			.5	30	---	0.33	0.33	0.65	0.65		
	C2-5	Capacitor, Fixed, .033 µF	CK06BX 333K	4			.5	30	16.8	0.109	0.436	0.32	1.28		
*		Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*		Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 100.6704 | SUM OF NKλ: 107.06

* Not listed in OP4219
** Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A01A05, A06, A07, A08	I/O 16 Bit 4 to 2 Multiplexer			1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
F2-5 H2-5	Circuit, Integrated	DM7214D	8						6.00	48.00	6.0	48.00		
H6	Circuit, Integrated	SN5404J	1					3.	6.00	6.00	6.0	6.00		
C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5	30	---	0.33	0.33	0.65	0.65		
C2-4	Capacitor, Fixed, .033μF	CK06BX 333K	3			.5	30	16.8	0.109	0.327	0.32	0.96		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1	CONDITION 2	SUM OF NKλ	SUM OF NKλ
		54.887	55.84

MSC/C FORM 1521-1DD (REV 3/72)

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01A09 | UNIT: I/O Test Interface | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
D2,E1	Circuit, Integrated	SN5400J	2					3.	6.0	12.00	6.0	12.00		
D3,F1, H2	Circuit, Integrated	SN5440J	3					3.	6.0	18.00	6.0	18.00		
D4,E4, F4,H4	Circuit, Integrated	SN5485J	4					3.	6.0	24.00	6.0	24.00		
E2,F2	Circuit, Integrated	SN54107J	2					3.	6.0	12.00	6.0	12.00		
E3,7 H1,7	Circuit, Integrated	SN5404J	4					3.	6.0	24.00	6.0	24.00		
E5,F5, H5	Circuit, Integrated	SN5406J	3					3.	6.0	18.00	6.0	18.00		
E6,F6, H6	Circuit, Integrated	SN54174J	3					3.	6.0	18.00	6.0	18.00		
F7	Circuit, Integrated	SN5437J	1					3	6.0	6.00	6.0	6.00		
D1,F3	Resistor, Fixed, 1000 Ω	D14M-01-102J	2			.5			0.65	1.30	0.65	1.30		
H3	Relay (Reed)	PRME1A 005B	1					286.	.00215	.00215	.00215	.00215		
** R1-22	Resistor, Fixed, 1000Ω 1/8W	RCR05G 102JS	22			.5		21.2	.0742	1.6324	0.3	6.6		
C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5		---	0.33	0.33	0.65	0.65		
C2-6	Capacitor, Fixed, .033μF	CK06BX 333K	5			.5		16.8	0.101	.575	0.32	1.6		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		—
CONDITION 1		CONDITION 2							SUM OF NKλ		SUM OF NKλ			

* Not listed in OP4219
** Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01A09 | UNIT: I/O Test Interface | ASSEMBLY: | SUBASSEMBLY: | SHEET 2 OF 2

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
*		Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1 | CONDITION 2 | SUM OF NKλ 135.49455 | SUM OF NKλ 142.38215

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A01A10 | UNIT: Pit Log Interface | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C3, D5, E5	Circuit, Integrated	SN54107J	3					3.	6.00	18.00	6.0	18.00		
C4, E6	Circuit, Integrated	SN5400J	2					3.	6.00	12.00	6.0	12.00		
C5	Circuit, Integrated	SN5440J	1					3.	6.00	6.00	6.0	6.00		
D1-3, E1-3	Circuit, Integrated	SN55107J	6					3.	6.00	36.00	6.0	36.00		
D6, F4-6	Circuit, Integrated	SN5404J	4					3.	6.00	24.00	6.0	24.00		
E7	Circuit, Integrated	SN54123J	1					3.	6.00	6.00	6.0	6.00		
F3, H3	Circuit, Integrated	SN54174J	2					3.	6.00	12.00	6.0	12.00		
F2	Resistor, Fixed, 3300 Ω	D14M-01-332J	1			.5			0.65	0.65	0.65	0.65		
H2, 4, 5	Resistor, Fixed, 1000 Ω	D14M-01-102J	3			.5			0.65	1.95	0.65	1.95		
R1-7	Resistor, Fixed, 1000 Ω 1/8 W	RCR05G 102J	7			.5		21.2	.0742	.5194	0.3	2.1		
R8, 9	Resistor, Fixed, 150 Ω 1 W	RCR32G 151J	2			.5		21.2	.0742	.1484	0.3	0.6		
R10, 11	Resistor, Fixed, 16K Ω 1/8 W	RCR05G 163J	2			.5		21.2	.0742	.1484	0.3	0.6		
* R12-15, 17, 18	Resistor, Fixed, 62 Ω 1/8 W	RCR05G 620J	6			.5		21.2	.0742	.4452	0.3	1.8		
R16	Resistor, Fixed, 510 Ω 1/8 W	RCR05G 511J	1			.5		21.2	.0742	.0742	0.3	0.3		
CONDITION 1		CONDITION 2							SUM OF NKλ		SUM OF NKλ			

* R17, R18 not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A01A10	Pit Log Interface			2 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C1,8,10	Capacitor, Fixed, 15μF	CSR13E 156KM	3			.5		---	0.33	0.99	0.65	1.95		
C2-7 9,11,12	Capacitor, Fixed, .033μF	CK06BX 333K	9			.5		16.8	0.109	.981	0.32	2.88		
C13	Capacitor, Fixed, .0022μF	CK06BX 222K	1			.5		16.8	0.109	.109	0.32	0.32		
CR1,2	Diode, Zener	JAN1N751A	2			.5		2.75	3.08	6.16	4.92	9.84		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1	CONDITION 2	SUM OF NKλ	126.4056	SUM OF NKλ	137.22

* Not listed in DP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A01A12	TWS Brg Cursor & Test Tgt Gen.			1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
B3,E6,7,F1-5, H1,2,3,5,P2	Circuit, Integrated	SN5404J	13					3.	6.00	78.00	6.0	78.00		
B4-6 E1-3	Circuit, Integrated	SN5485J	6					3.	6.00	36.00	6.0	36.00		
C2 D7	Circuit, Integrated	SN5400J	2					3.	6.00	12.00	6.0	12.00		
C3,D3, F7	Circuit, Integrated	SN54107J	3					3.	6.00	18.00	6.0	18.00		
C4-6	Circuit, Integrated	SN5483J	3					3.	6.00	18.00	6.0	18.00		
D4-6 E4	Circuit, Integrated	SN54197J	4					3.	6.00	24.00	6.0	24.00		
E5	Circuit, Integrated	SN54161J	1					3.	6.00	6.00	6.0	6.00		
F6,H3, H7	Circuit, Integrated	SN5440J	3					3.	6.00	18.00	6.0	18.00		
R1-5, 7,8,11	Resistor, Fixed, 1000Ω 1/8W	RCR05G 102JS	8			.5	30	21.2	.0742	.5936	0.3	2.4		
R6,9, 10	Resistor, Fixed, 62Ω 1/8W	RCR05G 620JS	3			.5	30	21.2	.0742	.2226	0.3	0.9		
C1,7	Capacitor, Fixed, 15μF	CSR13E 156KM	2			.5	30	---	0.33	0.66	0.65	1.3		
C2-6	Capacitor, Fixed, .033μF	CK06BX 333K	5			.5	30	16.8	0.109	.545	0.32	1.6		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		—
CONDITION 1				CONDITION 2					SUM OF NKλ	194.2512	SUM OF NKλ	216.43		

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

ADI A13

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A14	TWS 2/1, Tgt Position Computer			1 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
B7,F4 F7	Circuit, Integrated	SN5440J	3					3.	6.00	18.00	6.0	18.00		
C1-4 D2,E4	Circuit, Integrated	SN5483J	6					3.	6.00	36.00	6.0	36.00		
** C5,E5 H5-7	Circuit, Integrated	SN54174J	5					3.	6.00	30.00	6.0	30.00		
C6, D4,5	Circuit, Integrated	SN5485J	3					3.	6.00	18.00	6.0	18.00		
C7,D3 E1-3,F5	Circuit Integrated	SN5404J	6					3.	6.00	36.00	6.0	36.00		
D1	Circuit, Integrated	SN5400J	1					3.	6.00	6.00	6.0	6.00		
D6,7 E6,7	Circuit, Integrated	SN54164J	4					3.	6.00	24.00	6.0	24.00		
F6	Circuit, Integrated	SN54107J	1					3.	6.00	6.00	6.0	6.00		
H1,3	Circuit, Integrated (LSI)	TMS3112JC	2					-	4.84	9.68	4.84	9.68		
CR1	Diode (Zener)	JAN1N 3022BS	1					2.75	3.71	3.71	5.73	5.73		
R1,16	Resistor, Fixed, 1000Ω 1/8 W	RCR05G 102JS	2			.5		21.2	.0742	.1484	0.3	0.6		
R2-13	Resistor, Fixed, 7500Ω 1/8 W	RCR05G 752JS	12			.5		21.2	.0742	.8904	0.3	3.6		
R14, 15	Resistor, Fixed, 100Ω 1/4 W	RCR07G 101JS	2			.5		21.2	.0742	.1484	0.3	0.6		
* C1,6	Capacitor, Fixed, 15μF	CSR13E 156KM	2			.5		---	0.33	0.66	0.65	1.3		—
CONDITION 1		CONDITION 2							SUM OF NKλ		SUM OF NKλ			

* Not listed in OP4219

** Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

A01 A13

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A19 | UNIT: 7W52/1 Tgt Position Computer | ASSEMBLY: | SUBASSEMBLY: | SHEET 2 OF 2

	DEVICE IDENTIFICATION									FAILURE RATE IN FPM HOURS					
										CONDITION 1		CONDITION 2			
	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	BASE λ	TOTAL NKλ	BASE λ	TOTAL NKλ	PERCENT	DATA SOURCE
*	C2-5, 7	Capacitor, Fixed, .033μF	CK06BX 333K	5			.5	30	16.8	0.109	.545	0.32	1.60		
*		Board, Stitchwire		1						0.17	.17	0.17	0.17		
*		Connector	100 Pin ELCO	1						0.06	.06	0.06	0.06		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 190.0122 | SUM OF NKλ: 197.34

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: R&FCS | EQUIPMENT: SCC | GROUP: A01A15 | UNIT: TWS Clock & Range Ring Gen. | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	COND. 1 BASE λ	COND. 1 TOTAL NKλ	COND. 2 BASE λ	COND. 2 TOTAL NKλ	PERCENT	DATA SOURCE
	D1-3 E7	Circuit, Integrated	SN54197J	4					3.	6.00	24.00	6.0	24.00		
	D4,E5 E4	Circuit, Integrated	SN5400J	3					3.	6.00	18.00	6.0	18.00		
	E1-3, F6,H6,7	Circuit, Integrated	SN54161J	6					3.	6.00	36.00	6.0	36.00		
	E4,F7	Circuit, Integrated	SN54S112J	2					3	6.00	12.00	6.0	12.00		
	E6,F1,2 H1-3,5	Circuit, Integrated	SN5404J	7					3.	6.00	42.00	6.0	42.00		
	F3	Circuit, Integrated	SN54157J	1					3.	6.00	6.00	6.0	6.00		
	F5,H4	Circuit, Integrated	SN5440J	2					3.	6.00	12.00	6.0	12.00		
*		Circuit, Integrated	SN54107J	1					3.	6.00	6.00	6.0	6.00		
	R1,2	Resistor, Fixed, 1000Ω	RCR05 102JS	2			.5	30	21.2	.0742	.1484	0.3	0.6		
	R3,4	Resistor, Fixed, 62Ω	RCR05 620JS	2			.5	30	21.2	.0742	.1484	0.3	0.6		
	C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5	30	---	0.33	0.33	0.65	0.65		
	C2-7	Capacitor, Fixed, .033μF	CK06BX 333K	6			.5	30	16.8	0.101	.654	0.32	1.92		
*		Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*		Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		
	CONDITION 1		CONDITION 2							SUM OF NKλ	157.5108	SUM OF NKλ	160.00		

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A01A17

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A18 | UNIT: TWS 1/2 Range & Brg Window Gen | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 2

	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	B3	Circuit, Integrated	SN54S112J	1					3.	6.00	6.00	6.0	6.00		
	B4 C1,2 D6,E7	Circuit, Integrated	SN5400J	5					3.	6.00	30.00	6.0	30.00		
	C3,4 D2	Circuit, Integrated	SN5440J	3					3.	6.00	18.00	6.0	18.00		
**	C5	Circuit, Integrated	SN54107J	1					3.	6.00	6.00	6.0	6.00		
	D1,3,7 E5,H2	Circuit, Integrated	SN5404J	5					3.	6.00	30.00	6.0	30.00		
	D4 E6 F1,H1,3	Circuit, Integrated	SN5485J	5					3.	6.00	30.00	6.0	30.00		
	D5	Circuit, Integrated	SN54157J	1					3	6.00	6.00	6.0	6.00		
	E1-3	Circuit, Integrated	SN54191J	3					3.	6.00	18.00	6.0	18.00		
	E4,F2-4 H4,5	Circuit, Integrated	SN54174J	6					3.	6.00	36.00	6.0	36.00		
	F5-7	Circuit, Integrated	SN5483J	3					3.	6.00	18.00	6.0	18.00		
	C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5	30	---	0.33	0.33	0.65	0.65		
	C2-6	Capacitor, Fixed, .033μF	CK06BX 333K	5			.5	30	16.8	0.109	0.545	0.32	1.6		
	R1,2	Resistor, Fixed, 62 Ω 1/8 W	RCR05G 620J	2			.5	30	21.2	.0742	.1484	0.3	0.6		
	R3	Resistor, Fixed, 1000 Ω 1/8 W	RCR05G 102J	1			.5	30	21.2	.0742	.0742	0.3	0.3		---

CONDITION 1 | CONDITION 2 | SUM OF NKλ | SUM OF NKλ

* Not listed in OP4219
** Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

A01A17

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A18	UNIT TWS 1/2 Range & Brg Window Gen.	ASSEMBLY	SUBASSEMBLY	SHEET 2 OF 2

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS — CONDITION 1: BASE λ	CONDITION 1: TOTAL NKλ	CONDITION 2: BASE λ	CONDITION 2: TOTAL NKλ	PERCENT	DATA SOURCE
*		Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*		Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1	CONDITION 2	SUM OF NKλ	199.3276	SUM OF NKλ	201.38

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A01A19	UNIT Strobe Buffer	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
F6, H5,6	Circuit, Integrated	SN5437J	3					3.	6.00	18.00	6.0	18.00		
C1	Capacitor, Fixed 15μF	CSR13E 156KM	1			.5	30	---	0.33	0.33	0.65	0.65		
C2-4	Capacitor, Fixed, .033μF	CK06BX 333K	3			.5	30	16.8	0.109	0.327	0.32	0.96		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		

CONDITION 1	CONDITION 2	SUM OF NKλ	18.887	SUM OF NKλ	19.84

*Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A01A20	UNIT I/O Storage Buffer	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
B5	Circuit, Integrated	SN5400J	1					3.	6.00	6.00	6.00	6.00		
B6, D1, E1,5 F1,5, H5	Circuit, Integrated	SN5404J	7					3.	6.00	42.00	6.00	42.00		
C5, D2,4,5 E2,4, F2,4, H3	Circuit Integrated	SN54174J	9					3.	6.00	54.00	6.00	54.00		
C6,7	Circuit, Integrated	SN5406J	2					3.	6.00	12.00	6.00	13.00		
D3, E3 F3, H4	Circuit, Integrated	SN5437J	4					3.	6.00	24.00	6.00	24.00		
A5,6, B7, D6,7 E6,7, F6,7, H6,7	Relay (Reed)	PRME1A 005B	11					286.	.00215	.02365	.00215	.02365		
R1-16	Resistor, Fixed, 62 Ω, 1/8 W	RCR05G 620J	16			0.5	30	21.2	.0742	1.1872	0.3	4.8		
R17,18	Resistor, Fixed, 1000 Ω, 1/8 W	RCR05G 102J	2			0.5	30	21.2	.0742	.1484	0.3	0.6		
C1	Capacitor, Fixed, 15µF	CSR13E 156KM	1			0.5	30	---	0.33	0.33	0.65	0.65		
C2-6	Capacitor, Fixed, .033µF	CK06BX 333K	5			0.5	30	16.8	0.109	.545	0.32	1.6		
*	Board, Stitchwire		1						0.17	0.17	0.17	0.17		
*	Connector	100 Pin ELCO	1						0.06	0.06	0.06	0.06		
CONDITION 1			CONDITION 2						SUM OF NKλ	140.46125	SUM OF NKλ	145.90365		

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

Data Not Available, Considered Part of LNGG HF RADAR.

SYSTEM CPIC	SUBSYSTEM RGECS	EQUIPMENT SCC	GROUP A02	UNIT PPI	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1: BASE λ	CONDITION 1: TOTAL NKλ	CONDITION 2: BASE λ	CONDITION 2: TOTAL NKλ	PERCENT	DATA SOURCE

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A03	UNIT True North	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
J1	Connector	10-521-810-27P	1						0.008	0.008	0.008	0.008		
M1	Magslip	314-188888-001	1						2.40	2.40	2.40	2.40		
T1	Torqsyn	VTSN23	1						11.12	11.12	11.12	11.12		

CONDITION 1	CONDITION 2	SUM OF NKλ	13.528	SUM OF NKλ	13.528

INHERENT RELIABILITY ANALYSIS WORKSHEET

A04 - Summary Sheet

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A04 | UNIT: Mount & Status (Right Drawer) | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
Basic Panel										15.863		17.033		
A01	Counter, Rounds	EVS15.11	1						4.20	4.20	4.20	4.20		
A02	Same as A01	EVS15.11	1						4.20	4.20	4.20	4.20		
A03	Same as A01	EVS15.11	1						4.20	4.20	4.20	4.20		
A04	Same as A01	EVS15.11	1						4.20	4.20	4.20	4.20		
A05	Radar Interface									129.6508		174.756		
—	Resistor Board									6.72		9.36		
A06	Test Panel									45.9968		61.44		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 215.0306 | SUM OF NKλ: 279.389

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A04 | UNIT: Basic [illegible] | ASSEMBLY: | SUBASSEMBLY: | SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
S1	Switch (Mod.) (Rotary)	JV9032	1					.96	0.216	0.216	0.216	0.216		
T1	Transformer	PAB-617	1					.97	0.194	0.194	0.194	0.194		
* TB2	Board, Terminal		1						0.17	0.17	0.17	0.17		
XDS 1-7	Indicator	800-5-A2C2-J3-L2-	7						1.631	11.417	1.631	11.417		
** K1	Relay	M5757/23-005	1					286	0.572	0.572	0.572	0.572		
** CR1	Diode	1N645	1					4.33	3.16	3.16	4.33	4.33		
** J4	Connector	204738-2	1						0.014	0.014	0.014	0.014		
** J5, 6	Connector	00-7008-41-156-003	2						0.06	0.12	0.06	0.12		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 15.863 | SUM OF NKλ: 17.033

* Not listed in Honeywell Prediction

** Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP AD4A01	UNIT Counter, Rounds	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
–	Counter, Rounds	EVS 15.11	1						4.20	4.20	4.20	4.20		
														—

CONDITION 1	CONDITION 2	SUM OF NKλ	4.20	SUM OF NKλ	4.20

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A0-1A05	R[illegible]			1 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C1,3,5,8,9,12,14,17,18,26-28, 35,37,39,42,43														
	Capacitor Fixed 15uF	CSR13E 156[illegible]	17			.5		---	0.33	5.61	0.65	11.05		
C2,4,6,7,10,13,15,16,19,20,23, 25,29,30,33,34,36,38,40,41														
	Capacitor, Fixed, .033uF	CK06BX 333K	20			.5		16.8	0.109	2.18	0.32	6.4		
C11	Capacitor, Fixed, 5pF	CM05CD 050DP3	1			.5		11.5	0.024	0.024	0.039	0.039		
C21, 22	Capacitor, Fixed, .1uF	CK06BX 104K	2			.5		16.8	0.109	0.218	0.32	0.64		
C24	Capacitor, Fixed, 10pF	CM05CD 100DP3	1			.5		11.5	0.024	0.024	0.039	0.039		
C31 32	Capacitor, Fixed, 47pF	CM05FD 470JP3	2			.5		11.5	0.024	0.048	0.039	0.078		
Q1,3-5, 7,9	Transistor, NPN	JAN2N 2222A	6			.5		1.03	0.15	2.70	0.70	4.20		
Q2,6, 8	Transistor, PNP	JAN2N 2907A	3			.5		1.03	1.38	4.14	3.15	9.45		
CR1	Diode, Zener	JAN1N 753A	1			.5		2.75	3.08	3.08	4.92	4.92		
CR2	Diode, Zener	JAN1N 3022A	1			.5		2.75	3.71	3.71	5.73	5.73		
CR3, 5,6	Diode, Switching	JAN1N 914	3			.5		1.33	1.86	5.58	2.95	8.85		
CR4, 7,8	Diode, Zener	JAN1N 3826	3			.3		2.75	3.71	11.13	5.73	17.19		—

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A04A05	Radar Interface			2 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
R1,2, 19,20	Resistor, Fixed, 2.7Ω	RCR07G 2R7J	4	.5W		.5		21.2	.0742	.2968	0.3	1.2		
R3	Resistor, Fixed, 5600Ω	RCR05G 562J	1			.5		21.2	.0742	.0742	0.3	0.3		
R3, 12,13	Resistor, Fixed, 4700Ω	RCR05G 472J	3			.5		21.2	.0742	.2226	0.3	0.9		
* R5	Resistor, Fixed, 1600Ω	RCR05G 162J	1			.5		21.2	.0742	.0742	0.3	0.3		
R6, 60	Resistor, Fixed, 47Ω	RCR07G 470J	2			.5		21.2	.0742	.1484	0.3	0.6		
R7, 59	Resistor, Fixed, 300Ω	RCR05G 301J	2			.5		21.2	.0742	.1484	0.3	0.6		
R8	Resistor, Variable, 2KΩ	76PR2K (RTR12DP202R)	1			.5		0.02	.924	.924	1.18	1.18		
R9, 63	Resistor, Fixed, 220Ω	RCR07G 221J	2			.5		21.2	.0742	.1484	0.3	0.6		
R10,11, 56	Resistor, Fixed, 3300Ω	RCR05G 332J	3			.5		21.2	.0742	.2226	0.3	0.9		
R14, 15	Resistor, Fixed, 39Ω	RCR05G 390J	2			.5		21.2	.0742	.1484	0.3	0.6		
R16,25,44, 50,52,61,64	Resistor, Fixed, 1KΩ	RCR05G 102J	7			.5		21.2	.0742	.5194	0.3	2.1		
R17,18, 23,26,62	Resistor, Fixed, 2KΩ	RCR05G 202J	5			.5		21.2	.0742	.371	0.3	1.5		
R21	Resistor, Fixed, 120Ω	RCR07G 121J	1			.5		21.2	.0742	.0742	0.3	0.3		
R22, 33,53	Resistor, Fixed, 100Ω	RCR07G 101J	3			.5		21.2	.0742	.2226	0.3	0.9		—
CONDITION 1		CONDITION 2							SUM OF NKλ		SUM OF NKλ			

* Not listed in Honeywell Prediction.

INHERENT RELIABILITY
ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: 46-1A05 | UNIT: [illegible] | ASSEMBLY: | SUBASSEMBLY: | SHEET 3 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
* R26	Resistor, Fixed, 1500Ω	RCR05G 152J	1			[illegible]		21.2	.0742	.0742	0.3	0.3		
R27,28, 30-32	Resistor, Fixed, 2.2KΩ	RCR05G 222J	5			.5		21.2	.0742	.371	0.3	1.5		
R29	Resistor, Fixed, 470Ω	RCR05G 471J	1			.5		21.2	.0742	.0742	0.3	0.3		
R34	Resistor, Fixed, 150KΩ	RCR05G 154J	1			.5		21.2	.0742	.0742	0.3	0.3		
R35	Resistor, Variable, 500Ω	76PR500 (RTR)	1			.5		0.02	.924	.924	1.18	1.18		
R36	Resistor, Fixed, 130Ω	RCR07G 131J	1			.5		21.2	.0742	.0742	0.3	0.3		
R37-41, 45-49	Resistor, Fixed, 200Ω	RCR05G 201J	10			.5		21.2	.0742	.742	0.3	3.0		
R42, 43	Resistor, Fixed, 5100Ω	RCR05G 512J	2			.5		21.2	.0742	.1484	0.3	0.6		
R50, 55	Resistor, Fixed, 5KΩ	RCR05G 502J	2			.5		21.2	.0742	.1484	0.3	0.6		
R54	Resistor, Fixed, 10KΩ	RCR05G 103J	1			.5		21.2	.0742	.0742	0.3	0.3		
R57	Resistor, Fixed, 5600Ω	RCR05G 562J	1			.5		21.2	.0742	.0742	0.3	0.3		
R58	Resistor, Fixed, 4700Ω	RCR05G 472J	1			.5		21.2	.0742	.0742	0.3	0.3		
R65, 66	Resistor, Fixed, 68Ω	RCR07G 680J	2			.5		21.2	.0742	.1484	0.3	0.6		

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

* Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A04A05	UNIT Radar Interface	ASSEMBLY	SUBASSEMBLY	SHEET 4 OF 4

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	U1	Amplifier, Differential	HA-Z-2520	1					3.	6.00	6.00	6.0	6.00		
	U4	Circuit, Integrated	SN52510AT	1					3.	6.00	6.00	6.0	6.00		
	U1,2	Circuit, Integrated	SN5404J	2					3.	6.00	12.00	6.0	12.00		
	U3	Circuit, Integrated	SN5400J	1					3.	6.00	6.00	6.0	6.00		
	U4	Circuit, Integrated	SN5410J	1					3.	6.00	6.00	6.0	6.00		
	U5,6	Circuit, Integrated	SN54123J	2					3.	6.00	12.00	6.0	12.00		
	U7-9	Circuit, Integrated	SN55110J	3					3.	6.00	18.00	6.0	18.00		
	U10-12	Circuit, Integrated	SN55107J	3					3.	6.00	18.00	6.0	18.00		
*		PW Board		2						0.17	0.34	0.17	0.34		
*		Connector		2						0.06	0.12	0.06	0.12		
*	U2	Delay Circuit	7119	1						0.15	0.15	0.15	0.15		

CONDITION 1	CONDITION 2	SUM OF NKλ	129.6508	SUM OF NKλ	174.756

*Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A04 | UNIT: Resistor Board | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
R1	Resistor, Fixed, 1.62 Ω	RWR78S 1R62FM	1			.5		28.	0.56	0.56	0.78	0.78		
R2	Resistor, Fixed, 2.37 Ω	RWR78S 2R37FM	1			.5		28.	0.56	0.56	0.78	0.78		
R3	Resistor, Fixed, 4.02 Ω	RWR74S 4R02FM	1			.5		28.	0.56	0.56	0.78	0.78		
R4	Resistor, Fixed, 0.787 Ω	RWR80S R787FM	1			.5		28.	0.56	0.56	0.78	0.78		
R5,6, 9	Resistor, Fixed, 0.59 Ω	RWR80S R590FM	3			.5		28.	0.56	1.68	0.78	2.34		
R7	Resistor, Fixed, 0.226 Ω	RWR89S R226FM	1			.5		28.	0.56	0.56	0.78	0.78		
R8	Resistor, Fixed, 0.332 Ω	RWR89S R332FM	1			.5		28.	0.56	0.56	0.78	0.78		
R10	Resistor, Fixed, 0.187 Ω	RWR80S R187FM	1			.5		28.	0.56	0.56	0.78	0.78		
R11, 12	Resistor, Fixed, 0.147 Ω	RWR80S R147FM	2			.5		28.	0.56	1.12	0.78	1.56		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 6.72 | SUM OF NKλ: 9.36

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	R&FCS	SCC	A04A06	Test Panel			1 OF 3

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL (DEVICE IDENTIFICATION)	PART NUMBER (DEVICE IDENTIFICATION)	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
J1	Connector	204738-2	1						0.014	0.014	0.014	0.014		
DS1-16	Diode, Light Emitting	2L55RT LFL5/15	16			.5			1.0	16.00	1.0	16.00		
S1,3,4,6,24	Switch (Toggle)	MS35059-	5					0.96	0.144	0.72	0.144	0.72		
S2,5	Switch	357	2					0.96	0.144	0.288	0.144	0.288		
S23	Switch (Push Button)	MS25089-	1					0.96	0.192	0.192	0.192	0.192		
S7-22	Switch (Toggle)	MS27718-	16					0.96	0.144	2.304	0.144	2.304		

CONDITION 1

CONDITION 2

SUM OF NKλ

SUM OF NKλ

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A04A06 | UNIT: Circuit, Pulse Forming | ASSEMBLY: | SUBASSEMBLY: | SHEET 2 OF 3

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C1-3	Capacitor, Fixed, 15μF	CSR13E 156KM	3			.5	30	---	0.33	0.99	0.65	1.95		
C4, 5	Capacitor, Fixed, .01μF	CKR06CW 103MP	2			.5	30	16.8	0.109	0.218	0.32	0.64		
* CR3, 5,7,8	Diode	JAN1N 4454	4			.5	30	4.33	1.86	7.44	2.77	11.08		
* CR4, 6	Diode	JAN1N 4245	2			.5	30	3.26	3.26	6.52	6.43	12.86		
Q1, 3	Transistor (NPN)	JAN2N 2222A	2			.5	30	1.03	0.45	0.9	0.7	1.4		
Q2, 4	Transistor (NPN)	JAN2N 3501	2			.5	30	1.03	0.45	0.9	0.66	1.32		
K1, 2	Relay	M5757/9 -031	2					286	0.572	1.144	0.572	1.144		
K3, 4	Relay	M5757/19 -019	2					286	0.572	1.144	0.572	1.144		
** R1,2,7, 9,11,14	Resistor, Fixed, 1000Ω	RCR07G 102J	6			.5	30	21.2	.0742	.4452	0.3	1.8		
** R3	Resistor, Fixed, 2.7Ω	RCR20G 2R7J	1			.5	30	21.2	.0742	.0742	0.3	0.3		
** R4, 5	Resistor, Fixed, 15KΩ	RCR07G 153J	2			.5	30	21.2	.0742	.1484	0.3	0.6		
** R6, 12	Resistor, Fixed, 150Ω	RCR07G 151J	2			.5	30	21.2	.0742	.1484	0.3	0.6		
R8, 13	Resistor, Fixed, 10Ω	RCR07G 100J	2			.5	30	21.2	.0742	.1484	0.3	0.6		
R10	Resistor, Fixed, 100Ω	RCR07G 101J	1			.5	30	21.2	.0742	.0742	0.3	0.3		—
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

* Not listed in Honeywell Prediction (All Diodes lumped as 8, 4454's)

** In Honeywell Prediction, all R's lumped as 15, RLR07C's.

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC | SUBSYSTEM RGFCS | EQUIPMENT SCC | GROUP A04A06 | UNIT Circuit Pulse Forming | ASSEMBLY | SUBASSEMBLY | SHEET 3 OF 3

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Z1	Circuit, Integrated	SN54123J	1					3.	6.00	6.00	6.0	6.0		
*		PC Board		1						0.17	0.17	0.17	0.17		
*		Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1 | CONDITION 2 | SUM OF NKλ 45.9968 | SUM OF NKλ 61.44

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A05 | UNIT: System Status (Control Panel) | ASSEMBLY: | SUBASSEMBLY: | SHEET ___ OF ___

										Failure Rate in FPM Hours					
	Device Identification									Condition 1		Condition 2			
IND	Nomenclature and Card/Circuit Symbol	Part Number	Qty N	Part Rating	Actual Stress	Stress Ratio	Temp °C	Env Factor K	Base λ	Total NKλ	Base λ	Total NKλ	Percent	Data Source
A8, 13	BCD Shaft Encoder	SNB11-13P20	2						3.0	6.0	3.0	6.0		
A1-3, 4-7, 9-12	Switch (Push)	800-5-A.....	10					0.96	0.192	1.92	0.192	1.92		
* S1,2	Switch, Thumbwheel	7-H-21923	2						3.0	6.0	3.0	6.0		
* TB1,2	Terminal Board	37TB16	2						0.17	0.34	0.17	0.34		
* XDS2, 3,5	Indicator	800-5-A2C2-J3-12	3						1.631	4.893	1.631	4.893		
**	Counter	4Y-8829-6	1						0.254	0.254	0.254	0.254		
**	Counter, Degree	3Y-9992-R	1						0.254	0.254	0.254	0.254		
**	Range Gear Train	1099	1						0.9	0.9	0.9	0.9		
**	Bearing Gear Train	1098	1						0.9	0.9	0.9	0.9		
**	Wind Data Input Module		1						3.0	3.0	3.0	3.0		
**	Indicator		22						1.631	35.882	1.631	35.882		
CONDITION 1			CONDITION 2						SUM OF NKλ	60.343	SUM OF NKλ	60.343		

*Not listed in Honeywell Prediction
**Not listed in OP 4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06-Summary Sheet

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
EPIC	RGFCS	SCC	A06	Chopper Converter			1 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
A01	Analog (Card A1)									96.8725		135.512		
A02	Logic (Card A2)									80.764		86.764		
A03	Bridge (Card A3)									56.0826		102.114		
A05	Differential Amp.									46.7986		57.604		
A06	A/D Converter									21.6034		26.114		
A07	Same as A06									21.6034		26.114		
A11	Storage Register & Driver (Card A1)									81.0702		97.121		
A12	Bridge Sine-Cosine (Card A2)									64.692		106.814		
A13	Reference & Quadrant Switching (Card A3)									57.9577		71.038		
A15	Power Amplifier (Card A4)									33.8906		56.076		
A16	Same as A01									96.8725		135.512		
A17	Same as A02									80.764		86.764		
A18	Same as A03									56.0826		102.114		
A21	D/A Converter									42.2586		46.294		—

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06-Summary Sheet

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A06	UNIT Upper Converter	ASSEMBLY	SUBASSEMBLY	SHEET 2 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
A22	Same as A21									42. 2586		46. 294		
A23	Relay Logic									12. 344		16. 894		
A24	16 BIT 4 to 1 Multiplex									30. 9894		32. 394		
A25	Same as A24									30. 9894		32. 394		
A26	Same as A11									81. 0702.		87. 124		
A27	Same as A12									64. 692		106. 814		
A28	Same as A13									57. 9577		71. 038		
A30	Same as A15									33. 8906		56. 078		
A31	Same as A01									96. 8725		135. 512		
A32	Same as A02									80. 764		86. 764		
A33	Same as A03									56. 0826		102. 114		
A35	Analog (Card A1)									95. 0435		131. 662		
A36	Logic (Card A2)									80. 764		86. 764		
A37	Bridge (Card A3)									56. 0826		102. 114		
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06-Summary Sheet

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A06 | UNIT: Upper Converter | ASSEMBLY: | SUBASSEMBLY: | SHEET 3 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
A38	Same as A23									12.344		16.894		
A39	Same as A24									30.9894		32.394		
A40	Same as A24									30.9894		32.394		
A41	Same as A11									81.0702		87.124		
A42	Same as A12									64.692		106.814		
A43	Same as A13									57.9577		71.038		
A45	Same as A15									33.8906		56.078		
A46	Same as A01									96.8725		135.512		
A47	Same as A02									80.764		86.764		
A48	Same as A03									56.0826		102.114		
A50	Same as A35									95.0435		131.662		
A51	Same as A36									80.764		86.764		
A52	Same as A37									56.0826		102.114		
A53	18 BIT Inverter Buffer									19.6224		23.074		—

CONDITION 1 | CONDITION 2 | SUM OF NKλ | SUM OF NKλ

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06 - Summary Sheet

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A06	UNIT Upper Converter	ASSEMBLY	SUBASSEMBLY	SHEET 4 OF 4

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS — CONDITION 1: BASE λ	CONDITION 1: TOTAL NKλ	CONDITION 2: BASE λ	CONDITION 2: TOTAL NKλ	PERCENT	DATA SOURCE
A54	Same as A53									19.6224		23.074		
A55	Same as A53									19.6224		23.074		
A56	Same as A11									81.0702		87.124		
A57	Same as A12									64.692		106.814		
A58	Same as A13									57.9577		71.038		
A60	Same as A15									33.8466		56.078		
-	Chassis									0.96		0.96		
CONDITION 1			CONDITION 2						SUM OF NKλ	2732.094	SUM OF NKλ	3658.822		

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06 A01 (A16, 31, 46) Analog (Card A1) *

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: A | UNIT: S/D Converter 26V | ASSEMBLY: 400HZ | SUBASSEMBLY: | SHEET 1 OF 2

IND	Nomenclature and Card/Circuit Symbol	Part Number	Qty N	Part Rating	Actual Stress	Stress Ratio	Temp °C	Env Factor K	Condition 1 Base λ	Condition 1 Total NKλ	Condition 2 Base λ	Condition 2 Total NKλ	Percent	Data Source
	Capacitor, Fixed,	CS13B	5			.5		---	0.33	1.65	0.65	3.25		
	Capacitor, Fixed,	CK06	5			.5		16.8	0.109	.545	0.32	1.60		
	Capacitor, Fixed,	CK05	2			.5		16.8	0.109	.218	0.32	0.64		
	Circuit, Integrated	ITT 946 5D	1					3.	6.0	6.00	6.00	6.00		
	Circuit, Integrated	U6A9936 594F	2					3.	6.0	12.00	6.00	12.00		
	Amplifier, Op.	SN72741L	4					3.	6.0	24.00	6.00	24.00		
	Amplifier, Op.	SN72301AL	2					3.	6.0	12.00	6.00	12.00		
	Diodes	JAN1N 914	14					4.33	1.86	26.04	2.95	41.30		
	Resistor, Fixed	RC	25					21.2	.0742	1.855	0.3	7.50		
	Resistor, Fixed	RNG5	5					0.67	.1005	.5025	0.15	0.75		
	Transformer		2						.194	.388	0.194	0.388		
	Transistor (PNP)	JAN 2N 4007	6					1.03	1.38	8.28	3.15	18.90		
	Transistor	JAN 2N 2907	2					1.03	1.38	2.76	3.15	6.30		
	Transistor	JAN 2N 2222	1					1.03	0.45	0.45	0.70	0.70		—
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

* Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A01 (A16,31,46) Analog (Card A1)*

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC		S/D Converter 26V 400 Hz			2 of 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN [illegible] HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	[illegible]	DATA SOURCE
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	SUM OF NKλ
		96.8725	135.572

*Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A02 (A17, 32, 36, 47, 51) Logic (Card A2)*

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1
CPIC	RGFCS	SCC					

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Capacitor, Fixed	CS13B	2			.5		---	0.33	0.66	0.65	1.30		
	Capacitor, Fixed	CK06	4			.5		16.8	0.109	0.436	0.32	1.28		
	Circuit, Integrated	SN7406J	3					3.	6.00	18.00	6.00	18.00		
	Circuit, Integrated	SN7404J	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	SN7416J	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	SN74193J	3					3.	6.00	18.00	6.00	18.00		
	Circuit, Integrated	SN7410J	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	ITT 9465D	2					3.	6.00	12.00	6.00	12.00		
	Circuit, Integrated	U6A99365 9XF	2					3.	6.00	12.00	6.00	12.00		
	Resistor, Fixed, 1/4W	RC	8			.5		21.2	.0742	.5936	0.3	2.40		
	Resistor, Fixed, 1/2W	RC	12			.5		21.2	.0742	.8904	0.3	3.60		
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	44 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	80.764	SUM OF NKλ	86.764

*Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A03 (A18, 33, 37, 48, 52) Bridge (Card A3) *

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1
EPIC	RGFCS	SCC					

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL (DEVICE IDENTIFICATION)	PART NUMBER (DEVICE IDENTIFICATION)	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Capacitor, Fixed	CS13B	4			.5		---	0.33	1.32	0.65	2.60		
	Capacitor, Fixed	CK05	3			.5		16.8	0.109	0.327	0.32	0.96		
	Capacitor, Fixed	CK06	2			.5		16.8	0.109	0.218	0.32	0.64		
	Diode	JAN1N 914	2			.5		4.33	1.86	3.72	2.95	5.90		
	Resistor, Fixed	RN65	42			.5		0.67	.1005	4.221	0.15	6.30		
	Resistor, Fixed	RC	3			.5		21.2	.0742	.2226	0.3	0.90		
	Resistor, Fixed	RBR52	21			.5		0.87	0.87	18.27	1.03	21.63		
	Transistor	JAN 2N4007	16			.5		1.03	1.38	22.08	3.15	50.40		
	Transistor	JAN 2N 2907	4			.5		1.03	1.38	5.52	3.15	12.60		
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	56.0826	SUM OF NKλ	102.114

*Components not itemized in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A06A05	UNIT Differential Amplifier	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C1-8, 11-26	Capacitor, Fixed 0.1µF 100V	M39014/02 -0270 (CKR)	24			.5		16.8	0.109	2.616	0.32	7.68		
C9, 10	Capacitor, Fixed 18µF 50V	M39003/01 -2619	2			.5		---	0.33	0.66	0.65	1.30		
* R1,7,8,14,15, 21,22,28,29,35,36	Resistor, Fixed	RLR07	11			.5		1.38	.2898	3.1878	0.52	5.72		
R2-5,9-12,16-19, 23-26,30-33,37-40	Resistor, Fixed 510Ω	RNC55J5 111FM	24			.5		0.67	.1005	2.412	0.15	3.60		
R6,13,20, 27,34,41	Resistor, Fixed 10KΩ ¼W	RLR07C 103JM	6			.5		1.38	.2898	1.7388	0.52	3.12		
TP1-3	Jack, Test	M37010035	3						–	–	–	–		
Z1-6	Amplifier, Operational	M38510/ 10101CCB	6					3.	6.00	36.00	6.00	36.00		
**	PW Board		1						0.17	0.17	0.17	0.17		
**	Connector		1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	46.7986	SUM OF NKλ	57.604

* Honeywell Prediction indicates these resistors not installed.

** Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A05A06,A07

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP	UNIT A/D Converter	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
C1,3	Capacitor, Fixed, 18µF	M39003/01-2619	2	50V		.5		---	0.33	0.66	0.65	1.30		
C2,4 6-8	Capacitor, Fixed, 0.1µF	M39014/02-0270	5	100V		.5		16.8	0.109	0.545	0.32	1.60		
C5	Capacitor, Fixed, 100µF	M39003/01-2502	1	10V		.5		---	0.33	0.33	0.65	0.65		
R2	Resistor, Fixed 27KΩ 1/4 W	RLR07C 273JM	1			.5		1.38	.2898	.2898	0.52	0.52		
R3,4 7,8	Resistor, Fixed	RNC55	4			.5		0.67	.1005	.402	0.15	0.60		
R10	Resistor, Fixed, 2.7MΩ 1/4 W	RCR07G 275JM	1			.5		21.2	.0742	.0742	0.3	0.30		
R15, 16	Resistor, Fixed 110KΩ 1/4 W	RLR07C 104JM	2			.5		1.38	.2898	.5796	0.52	1.04		
* R1,5 11-14	Resistor, Fixed, 10KΩ 1/4 W	RLR07C 103JM	6			.5		1.38	.2898	1.7388	0.52	3.12		
TP 1-3	Jack, Test	37010035-001	3						—	—	—	—		
Z1	Converter, A/D	AD540-12-B1N	1						16.8	16.8	16.8	16.8		
**	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		
CONDITION 1		CONDITION 2							SUM OF NKλ	21.6034	SUM OF NKλ	26.114		

* R9 apparently dropped in Honeywell Prediction

** Not listed in OP4210

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A11(A26, 41, 56) Storage Register & Driver *

SYSTEM: CPIC	SUBSYSTEM: RGFCS	EQUIPMENT: SCC	GROUP	UNIT: (Card A1)	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Capacitor, Fixed	CS13B	2			.5	30	---	0.33	0.66	0.65	1.30		
	Capacitor, Fixed	CK06BX 472K	2			.5	30	16.5	0.109	0.218	0.32	0.64		
	Circuit, Integrated	SN7474J	5					3.	6.00	30.00	6.00	30.00		
	Circuit, Integrated	46A33726 59X	4					3.	6.00	24.00	6.00	24.00		
	Circuit, Integrated	SN7406J	4					3.	6.00	24.00	6.00	24.00		
	Resistor, Fixed 1/2W	RC	12			.5	30	21.2	.0742	.8904	0.3	3.60		
	Resistor, Fixed 1/4W	RC	9			.5	30	21.2	.0742	.6678	0.3	2.70		
	Transistor	JAN 2N 2222	1			.5	30	1.03	0.45	0.45	0.7	0.70		
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		
CONDITION 1			CONDITION 2						SUM OF NKλ	81.0702	SUM OF NKλ	87.124		

* Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A12 (A27, 42, 57) Bridge, Sine-Cosine (Card A2)*

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	Condition 1 BASE λ	Condition 1 TOTAL NKλ	Condition 2 BASE λ	Condition 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Capacitor, Fixed	CS13B...	2			.5		---	0.33	0.66	0.65	1.30		
	Capacitor, Fixed	CK06...	2			.5		16.8	0.109	0.218	0.32	0.64		
	Circuit, Integrated	FU6A77 41393	2					3.	6.0	12.00	6.00	12.00		
	Resistor, Fixed	RN65..	40			.5		0.67	.1005	4.02	0.15	6.00		
	Resistor, Fixed	RBR-52	23			.5		0.87	0.87	20.01	1.03	23.69		
	Transistor PNP	2N4007	16			.5		1.03	1.38	22.08	3.15	50.40		
	Transistor	JAN2N 2907	4			.5		1.03	1.38	5.52	3.15	12.60		
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	64.692	SUM OF NKλ	106.814

*Components not itemized in 0T74219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A13 (A28, 43, 58) Reference & Quadrant Switching (Card A3) *

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC					1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Capacitor, Fixed	C513B...	3			.5		---	0.33	0.99	0.65	1.95		
	Capacitor, Fixed	CK06B...	3			.5		16.8	0.109	0.327	0.32	0.96		
	Circuit, Integrated	FU6A77 41393	4					3.	6.00	24.00	6.00	24.00		
	Circuit, Integrated	FU6A79 3659X	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	SN7474J	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	SN7406 J	1					3.	6.00	6.00	6.00	6.00		
	Circuit, Integrated	ITT 9465D	1					3.	6.00	6.00	6.00	6.00		
	Resistor, Fixed	RN65....	11			.5		0.67	.1005	1.1055	0.15	1.65		
	Resistor, Fixed	RC....	16			.5		21.2	.0742	1.1872	0.3	4.80		
	Transformer		1						0.194	0.194	0.194	0.194		
	Transistor	2N2222	1			.5		1.03	0.45	0.45	0.70	0.70		
	Transistor	JAN 2N 4007	4			.5		1.03	1.38	5.52	3.15	12.60		
	PW Board		1						0.17	0.17	0.17	0.17		
	Connector		1						0.014	0.014	0.014	0.014		—
CONDITION 1			CONDITION 2						SUM OF NKλ	57.9577	SUM OF NKλ	71.038		

*Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A15 (A30, 45, 60) Power Amplifier (Gr 1 A4)*

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	R&FCS	SCC					1 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Amplifier, Operational	SN72741L	2					3.	6.00	12.00	6.00	12.00		
	Capacitor, Fixed	CS13R...	6			.5		---	0.33	1.98	0.65	3.90		
	Capacitor, Fixed	CK06...	9			.5		6.8	0.109	.981	0.32	2.88		
	Capacitor, Fixed	CK05...	2			.5		6.8	0.109	.218	0.32	0.64		
	Diode	JAN1N 914	4			.5		4.33	1.86	7.44	2.95	11.80		
	Resistor, Fixed	RC...	18			.5		21.2	.0742	1.3356	0.3	5.40		
	Resistor, Fixed	RN65...	4			.5		0.67	.1005	.402	0.15	0.60		
	Transformer		1						0.194	.194	0.194	0.194		
	Transistor PNP	JAN2N 2905	2			.5		1.03	1.38	2.76	3.15	6.30		
	Transistor NPN<1W	JAN2N 2219	2			.5		1.03	0.45	.9	0.7	1.40		
	Transistor PNP<1W	JAN2N 2907	2			.5		1.03	1.38	2.76	3.15	6.30		
	Transistor NPN<1W	2N2222A	2			.5		1.03	0.45	.9	0.7	1.40		
	Transistor	2N3766	4			.5		0.51	0.459	1.836	0.77	3.08		
	PW Board		1						0.17	0.17	0.17	0.17		—
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

*Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06 A15 (A30,45,60) Power Amplifier (Card A4)*

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC					2 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Connector		1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	33.8906	SUM OF NKλ	56.078

* Components not itemized in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06 A21, A22 D/A Converter

SYSTEM: CPIC | SUBSYSTEM: KGFCS | EQUIPMENT: SCC | GROUP: | UNIT: | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

	IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	Condition 1 BASE λ	Condition 1 TOTAL NKλ	Condition 2 BASE λ	Condition 2 TOTAL NKλ	PERCENT	DATA SOURCE
	C1,3,5, 7-9	Capacitor, Fixed, 0.1μF 100V	CKR06 M39014/02-0270	6			.5		16.8	.109	.654	0.32	1.92		
	C2,4	Capacitor, Fixed 18μF 50V	CSR13E M39003/01-2619	2			.5		---	0.33	0.66	0.65	1.30		
	C6	Capacitor, Fixed 100μF 10V	CSR13E M39014/02-0270	1			.5		---	0.33	0.33	0.65	0.65		
	R2,6, 9-13	Resistor, Fixed 10KΩ 1/4W	RLR07C 103JM	7			.5		1.38	.2898	2.0286	0.52	3.64		
	R3,4, 7,8	Resistor, Fixed	RNC55	4			.5		0.67	.1005	.402	0.15	0.60		
*	R1,5	Resistor, Variable, 10KΩ	RT26C2P 103	0			.5			–	–	–	–		
	TP 1,2	Jack, Test	M370-100 -35	2						–	–	–	–		
	Z1	Converter, D/A	DAC40-12U -CBI	1						20.0	20.0	20.00	20.00		
	Z2-4	Circuit, Integrated	SN54175J	3					3.	6.00	18.00	6.00	18.00		
**		PW Board		1						0.17	0.17	0.17	0.17		
**		Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 42.2586 | SUM OF NKλ: 46.294

* Apparently not used in production model
** Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A23,A38 Relay Logic

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 1
CPIC	RGFCS	SCC					

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	CR1-5	Diode	JAN1N 4454	5			.5		4.33	1.86	9.3	2.77	13.85		
	K1-5	Relay	M5757-19-019	5					286.	.572	2.86	0.572	2.86		
*		PC Board	1609-801	1						0.17	0.17	0.17	0.17		
*		Connector		1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	12.344	SUM OF NKλ	16.894

* Not listed in OP 4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A24 (A25,39,40) 16 BIT 4 to 1 Multiplexer

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: | UNIT: | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS, CONDITION 1: BASE λ	CONDITION 1: TOTAL NKλ	CONDITION 2: BASE λ	CONDITION 2: TOTAL NKλ	PERCENT	DATA SOURCE
C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5		---	0.33	0.33	0.65	0.65		
C2-4	Capacitor, Fixed, .033μF	CK06BX 333K	3			.5		6.8	0.109	.327	0.32	0.96		
R1,2	Resistor, Fixed, 62Ω, 1/4W	RCR07G 620J	2			.5		21.2	.0742	.1484	0.3	0.60		
Z1	Circuit, Integrated	SN5404J	1					3.	6.00	6.00	6.00	6.00		
Z2	Circuit, Integrated	SN5420J	1					3.	6.00	6.00	6.00	6.00		
Z3-5	Circuit, Integrated	DM7214J	3					3.	6.00	18.00	6.00	18.00		
*	PC Board	1606-801	1						0.17	0.17	0.17	0.17		
*	Connector		1						0.014	0.014	0.014	0.014		

CONDITION 1 | CONDITION 2 | SUM OF NKλ: 30.9874 | SUM OF NKλ: 32.394

* Not listed in OP 4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A35, A50 Analog (Card A1)*

SYSTEM: CPIC	SUBSYSTEM: RGFCS	EQUIPMENT: SCC	GROUP	UNIT: S/D Converter 115V	ASSEMBLY	SUBASSEMBLY	SHEET 1 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	Condition 1 BASE λ	Condition 1 TOTAL NKλ	Condition 2 BASE λ	Condition 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Amplifier, Operational	SN72741L	4					3.	6.0	24.00	6.00	24.00		
	Amplifier, Operational	SN72301AL	2					3.	6.0	12.00	6.00	12.00		
	Capacitor, Fixed	CS13B...	5			.5		---	0.33	1.65	0.65	3.25		
	Capacitor, Fixed	CK06....	7			.5		16.8	0.109	.763	0.32	2.24		
	Circuit, Integrated	FU6A9936 59X	2					3.	6.00	12.00	6.00	12.00		
	Circuit, Integrated	ITT 9465D	1					3.	6.00	6.00	6.00	6.00		
	Diode	JAN1N 914	13			.5		4.33	1.86	24.18	2.95	38.35		
	Resistor, Fixed	RN65	9			.5		0.67	.1005	.9045	0.15	1.35		
	Resistor, Fixed	RC...	20			.5		21.2	.0742	1.484	0.3	6.00		
	Transformer		2						0.194	.388	0.194	0.388		
	Transistor	2N4007	6			.5		1.03	1.38	8.28	3.15	18.90		
	Transistor	JAN2N 2907	2			.5		1.03	1.38	2.76	3.15	6.30		
	Transistor	JAN2N 2222	1			.5		1.03	0.45	0.45	0.70	0.70		
	PW Board		1						0.17	0.17	0.17	0.17		
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

*Components not itemized in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A35, A50 Analog (Card A1)*

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC		S/D Controller 115V			2 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Connector	41 Pin Type	1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	85.0435	SUM OF NKλ	131.662

*Components not itemized in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A06A53(A54,55) 18 BIT Inverter Buffer

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC					1 OF 1

	DEVICE IDENTIFICATION									FAILURE RATE IN FPM HOURS					
										CONDITION 1		CONDITION 2			
IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	BASE λ	TOTAL NKλ	BASE λ	TOTAL NKλ	PERCENT	DATA SOURCE
C1	Capacitor, Fixed, 15μF	CSR13E 156KM	1			.5		---	0.33	0.33	0.65	0.65		
C2,3	Capacitor, Fixed, .033μF	CK06BX 333K	2			.5		16.8	0.109	0.218	0.32	0.64		
R1-12	Resistor, Fixed 62Ω 1/4W	RCR07G 620J	12			.5		21.2	.0742	.8904	0.3	3.60		
Z1-3	Circuit, Integrated	SN5404J	3					3.	6.00	18.00	6.00	18.00		
*	PC Board	1604-801	1						0.17	0.17	0.17	0.17		
*	Connector		1						0.014	0.014	0.014	0.014		

CONDITION 1	CONDITION 2	SUM OF NKλ	19.6224	SUM OF NKλ	23.074

* Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	A06	Chassis			1 OF 1

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
J1-60	Connector	00-7008-141-154-032	60						0.014	0.84	0.014	0.84		
J61, 62	Connector	6-204692-6	2						0.06	0.12	0.06	0.12		

CONDITION 1

CONDITION 2

SUM OF NKλ: 0.96 (Condition 1); SUM OF NKλ: 0.96 (Condition 2)

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___
CPIC	RGFCS	SCC	A07 *	Computer H316R			

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Main Frame with 4K Memory	316R-0100	1						350.57	350.57		350.57		
	Power Supply	316R-0100	1						98.00	98.00		98.00		
	4K Memory	316R-02	1						57.75	57.75		57.75		
	High-Speed Arith.	316R-11	1						28.80	28.80		28.80		
	Real Time Clock	316R-12	1						5.06	5.06		5.06		

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	
			540.18		540.18

*Components not itemized in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

A08-Summary Sheet – Same As A06

SYSTEM CPIC	SUBSYSTEM RGFCS	EQUIPMENT SCC	GROUP A08	UNIT Lower Converter	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___

IND	DEVICE IDENTIFICATION		QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS				PERCENT	DATA SOURCE
	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER							CONDITION 1		CONDITION 2			
									BASE λ	TOTAL NKλ	BASE λ	TOTAL NKλ		
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: KGFCS | EQUIPMENT: SCC | GROUP: A09 | UNIT: Switchboard & Power Supply | ASSEMBLY: | SUBASSEMBLY: | SHEET 1 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	COND. 1 BASE λ	COND. 1 TOTAL NKλ	COND. 2 BASE λ	COND. 2 TOTAL NKλ	PERCENT	DATA SOURCE
CB1-10	Breaker, Circuit	M39019/3 –	10						0.5	5.00	0.5	5.00		
J1-5	Connector	204259-2	5						0.021	0.105	0.021	0.105		
K1-40	Relay	M5757/23-004	40					286.	0.572	22.88	0.572	22.88		
K41-43,45	Relay	M5757/16-003	4					286.	0.572	2.288	0.572	2.288		
K44	Flasher	F945	1						12.50	12.50	12.50	12.50		
M1	Meter, Time Totalizing	MS17325-5	1			.5		0.148	1.48	1.48	1.48	1.48		
* P1-5	Connector	204260-2	5						0.021	0.105	0.021	0.105		
PS1	Power Supply	37656742-001	1						54.00	54.00	54.00	54.00		
PS2	Power Supply	37656742-002	1						27.00	27.00	27.00	27.00		
S1,2	Switch, Linear	1853048	2						4.756	9.512	4.756	9.512		
S3-5	Switch, Rotary	S2JM-15	3						0.216	0.648	0.216	0.648		
S6	Switch, Rotary	S3JR-15	1						0.216	0.216	0.216	0.216		
T1	Transformer	HSM-200	1					0.97	0.194	0.194	0.194	0.194		
** CR1-30	Diode	1N914	30			.5		4.33	1.86	55.8	2.95	88.50		—
CONDITION 1			CONDITION 2						SUM OF NKλ		SUM OF NKλ			

* Not listed in Honeywell Prediction
** Not listed in OP4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM CPIC	SUBSYSTEM KGFCS	EQUIPMENT SCC	GROUP A09	UNIT Switchboard & Power Supply	ASSEMBLY	SUBASSEMBLY	SHEET 2 OF 2

	IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
**	K46	Relay	M527418-18	1					286	0.572	0.572	0.572	0.572		
**		Relay Connector	VBB/1PA/1-45	40						0.001	0.04	0.001	0.04		
**	J6-7	Connector	202515-3	2						0.008	0.016	0.008	0.016		

CONDITION 1	CONDITION 2	SUM OF NKλ	192.356	SUM OF NKλ	225.056

** Not listed in OP 4219

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___
CPIC	RGFCS	SCC	A10	I/O Panel (Left)			

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
J1-3	Connector	10-521810-19P	3						0.006	0.018	0.006	0.018		
J4, 7	Connector	MS3402D 20-27	2						0.008	0.016	0.008	0.016		
J6, 12	Connector	MS3402D 36-10	2						0.003	0.006	0.003	0.006		
J8, 11,15	Connector	MS3402D 40-56	3						0.015	0.045	0.015	0.045		
J9, 14	Connector	MS3402D 28-21	2						0.006	0.012	0.006	0.012		
J10	Connector	MS3402D 18-11	1						0.003	0.003	0.003	0.003		
J16	Connector	10-521817-52P	1						0.014	0.014	0.014	0.014		
FL1-6	Filter (RFI)	GF-4500-13, 14, 17	6						0.438	2.628	0.438	2.628		

CONDITION 1	CONDITION 2	SUM OF NKλ	2.742	SUM OF NKλ	2.742

INHERENT RELIABILITY
ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
EPIC	RGFCS	SCC	A11	I/O Panel (Right)			1 OF 1

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
J5	Connector	MS3402D-36-10	1						0.003	0.003	0.003	0.003		
J13	Connector	MS3402D-28-21	1						0.006	0.006	0.006	0.006		
J17	Connector	10-521-816-53	1						0.014	0.014	0.014	0.014		
* J18	Connector	MS3102A-28-21	1						0.006	0.006	0.006	0.006		
* J19	Connector	MS3102A-36-10	1						0.003	0.003	0.003	0.003		
J20	Connector	10-521-807-1	1						0.061	0.061	0.061	0.061		

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	
			0.093		0.093

*Not listed in Honeywell Prediction

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET ___ OF ___
CPIC	KGFCS	SCC		DOOR ASSEMBLY *			

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	Blower	ST682-YS	2						2.250	4.5	2.250	4.5		
	Filter	1075	1						.079	.079	.079	.079		

CONDITION 1	CONDITION 2	SUM OF NKλ	4.579	SUM OF NKλ	4.579

*Not listed in OP4219.

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM: CPIC | SUBSYSTEM: RGFCS | EQUIPMENT: SCC | GROUP: 1110 (REF 1857) | UNIT: CABLE HARNESS | ASSEMBLY:) | SUBASSEMBLY: | SHEET 1 OF 3

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	1832 CONNECTOR A09 P1	204260-2	1							.021				
	1832 CONNECTOR A09 P2	204260-2	1							.021				
	1832 CONNECTOR A09 P3	204260-2	1							.021				
	1832/1834 A09 P4	204260-2	1							.021				
	1832 A09 P5	204260-2	1							.021				
	1832 A09 P13	202516-3	1							.008				
	1832 A09 P14	202516-3	1							.008				
	1832 A01 P7	204693-6	1							.060				
	1832 A01 P8	204693-6	1							.060				
	x 1832 A01 P9	204693-6	1							.060				
	1834 A01 P10	204693-6	1							.060				
	1832 A01 P11	204693-6	1							.060				
	1832 CONNECTOR A01 H12	204739-2	1							.014				

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	REFCS	SCC	1110				2 OF 3

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	CONNECTOR 1832 A04 P6	204739-2	1						.014					
	1832/1834 A04P19	204739-2							.014					
	1834 A04 P16								.014					
	1834 A04 P17								.014					
	1832 A08 P22	204693-6							.060					
	1832 A08P23	204693-6							.060					
	1832 A07P24								.060					
	1832 A07P25								.060					
	1832 A07P21								.060					
	1832 A06P61	204693-6							.060					
	CONNECTOR 1832 A06P62	204693-6	1						.060					

CONDITION 1	CONDITION 2	SUM OF NKλ		SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET 3 OF 3
CPIC	RGFCS	SCC	1110				

IND	DEVICE IDENTIFICATION		QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS				PERCENT	DATA SOURCE
									CONDITION 1		CONDITION 2			
	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER							BASE λ	TOTAL NKλ	BASE λ	TOTAL NKλ		
	CONNECTOR 1834 J18	1856	1						.060					
	1834 J19	1856							.060					
	x A05 P26								.014					
	x A05 P27								.014					
	1835 P18	1081							.060					
	1835 P19	1081							.060					
	1835 A03 P15	10-521 -810-275							.008					
	1835 A02 P20								.056					
	CONNECTOR 1835 A02 P22		1						.056					

CONDITION 1	CONDITION 2	SUM OF NKλ	1.299	SUM OF NKλ	

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
C/IC	EGFCS	SCC	1507	RF PLUMBING			1 OF 2

IND	NOMENCLATURE AND CARD/CIRCUIT SYMBOL	PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	Condition 1 BASE λ	Condition 1 TOTAL NKλ	Condition 2 BASE λ	Condition 2 TOTAL NKλ	PERCENT	DATA SOURCE
	SHORTING PLATE	696	1						.001	.001				
	COAX TERMINATION	9020 NF	1						.003	.003				
	WAVEGUIDE	641	4						1.1	4.400				
	WAVEGUIDE	642	2						1.1	2.200				
	WAVEGUIDE	643	2						1.1	2.200				
	WAVEGUIDE	646	2						1.1	2.200				
	WAVEGUIDE	647	2						1.1	2.200				
	WAVE GUIDE ELBOW	632	1						1.1	1.100				
	WAVE GUIDE ELBO	633	1						1.1	1.100				
	BULK HEAD FLANG PRESSURE UNIT	668	1						1.1	1.100				
	SWITCH	1500	1						2.55	2.550				
	COUPLER	1501	1						1.1	1.100				
	DUMMY LOAD	1502	1						3.23	3.23 3.230				

CONDITION 1

CONDITION 2

SUM OF NKλ

SUM OF NKλ

INHERENT RELIABILITY ANALYSIS WORKSHEET

SYSTEM	SUBSYSTEM	EQUIPMENT	GROUP	UNIT	ASSEMBLY	SUBASSEMBLY	SHEET
CPIC	RGFCS	SCC	1507	ICF PLUMBING			2 OF 2

IND	DEVICE IDENTIFICATION: NOMENCLATURE AND CARD/CIRCUIT SYMBOL	DEVICE IDENTIFICATION: PART NUMBER	QTY N	PART RATING	ACTUAL STRESS	STRESS RATIO	TEMP °C	ENV FACTOR K	FAILURE RATE IN FPM HOURS: CONDITION 1 BASE λ	CONDITION 1 TOTAL NKλ	CONDITION 2 BASE λ	CONDITION 2 TOTAL NKλ	PERCENT	DATA SOURCE
	ECHO BOX	1503	1						5.000	5.000				
	COAX ADAPTER	1504	1						.005	.005				

CONDITION 1	CONDITION 2	SUM OF NKλ	SUM OF NKλ
		28.399	

APPENDIX D

SYSTEM CONTROL CONSOLE ASSEMBLIES/SUBASSEMBLIES THAT ARE PREDICTED TO FAIL 50 OR MORE TIMES PER MILLION HOURS OF OPERATION

SYSTEM CONTROL CONSOLE ASSEMBLIES/SUBASSEMBLIES THAT ARE PREDICTED TO FAIL 50 OR MORE TIMES PER MILLION HOURS OF OPERATION					
Reference Designation	Assembly/Subassembly	Condition 1		Condition 2	
		λ	MTBF	λ	MTBF
A01	Target and Director (Left Drawer)	2351	425	2463	406
A01A01	I/O Control Sequencer	195	5128	201	4975
A01A02	Director Bearing Error Generator and Buffer	189	5291	197	5076
A01A04	I/O Data Select/Buffer	101	9901	109	9174
A01A05	I/O 16-Bit 4 to 1 Multiplexer	55	18182	56	17857
A01A06	I/O 16-Bit 4 to 1 Multiplexer	55	18182	56	17857
A01A07	I/O 16-Bit 4 to 1 Multiplexer	55	18182	56	17857
A01A08	I/O 16-Bit 4 to 1 Multiplexer	55	18182	56	17857
A01A09	I/O Test Interface	136	7353	142	7042
A01A10	Pit Log Interface	126	7937	137	7299
A01A12	TWS Bearing Cursor and Test Target Generator	194	5155	216	4630
A01A13	TWS 2 Target Position Computer	190	5263	197	5076
A01A14	TWS 1 Target Position Computer	190	5263	197	5076
A01A15	TWS Clock and Range Ring Generator	158	6329	160	6250
A01A17	TWS 1 Range and Bearing Window Generator	199	5025	201	4975
A01A18	TWS 2 Range and Bearing Window Generator	199	5025	201	4975
A01A20	I/O Storage Buffer	140	7143	146	6849
-	Basic Panel	95	10526	113	8850
A04	Mount and Status (Right Drawer)	215	4651	279	3584
A04A05	Radar Interface	130	7692	175	5714
A04A06	Test Panel	46	21739	61	16393
A05	System Status (Control Panel)	60	16667	60	16667
A06	Upper Converter	2732	366	3659	273
A06A01	Analog (Card A1)	97	10309	136	7353
A06A02	Logic (Card A2)	81	12346	87	11494
A06A03	Bridge (Card A3)	56	17857	102	9804
A06A05	Differential Amplifier	47	21277	58	17241
A06A11	Storage Register and Driver (Card A1)	81	12346	87	11494
A06A12	Bridge, Sine-Cosine (Card A2)	65	15385	107	9346
A06A13	Reference and Quadrant Switching (Card A3)	58	17241	71	14085
A06A15	Power Amplifier (Card A4)	34	29412	56	17857
A06A16	Same as A01	97	10309	136	7353
A06A17	Same as A02	81	12346	87	11494
A06A18	Same as A03	56	17857	102	9804
A06A26	Same as A11	81	12346	87	11494
A06A27	Same as A12	65	15385	107	9346
A06A28	Same as A13	58	17241	71	14085
A06A30	Same as A15	34	29412	56	17857
A06A31	Same as A01	97	10309	136	7353
A06A32	Same as A02	81	12346	87	11494
A06A33	Same as A03	56	17857	102	9804
A06A35	Analog (Card A1)	95	10526	132	7576
A06A36	Logic (Card A2)	81	12346	87	11494
A06A37	Bridge (Card A3)	56	17857	102	9804
A06A41	Same as A11	81	12346	87	11494
A06A42	Same as A12	65	15385	107	9346
A06A43	Same as A13	58	17241	71	14085
A06A45	Same as A15	34	29412	56	17857
A06A46	Same as A01	97	10309	136	7353
A06A47	Same as A02	81	12346	87	11494
A06A48	Same as A03	56	17857	102	9804
A06A50	Same as A35	95	10526	132	7576
A06A51	Same as A36	81	12346	87	11494
A06A52	Same as A37	56	17857	102	4804
A06A56	Same as A11	81	12346	87	11494
A06A57	Same as A12	65	15385	107	9346
A06A58	Same as A13	58	17241	71	14085
A06A60	Same as A15	34	29412	56	17857
A07	Computer H316R	540	1852	540	1852
	Main Frame with 4K Memory	351	2849	351	2849
	Power Supply	98	10204	98	10204
	4K Memory	58	17241	58	17241
A08	Lower Converter (Same Summary as A06)	2732	366	3659	273
A09	Switchboard and Power Supply	192	5208	225	4444